DISCOVERY

Monthly Notebook

A Scrap of White Paper
Berzelius, Inventor of 'Protein'
Norway's Atomic Pile
A One-sided Atomic Arms Race
Waste of Coal *v.* Waste of Words

Radioactive Dust as a Weapon
Prof. HANS THIRRING

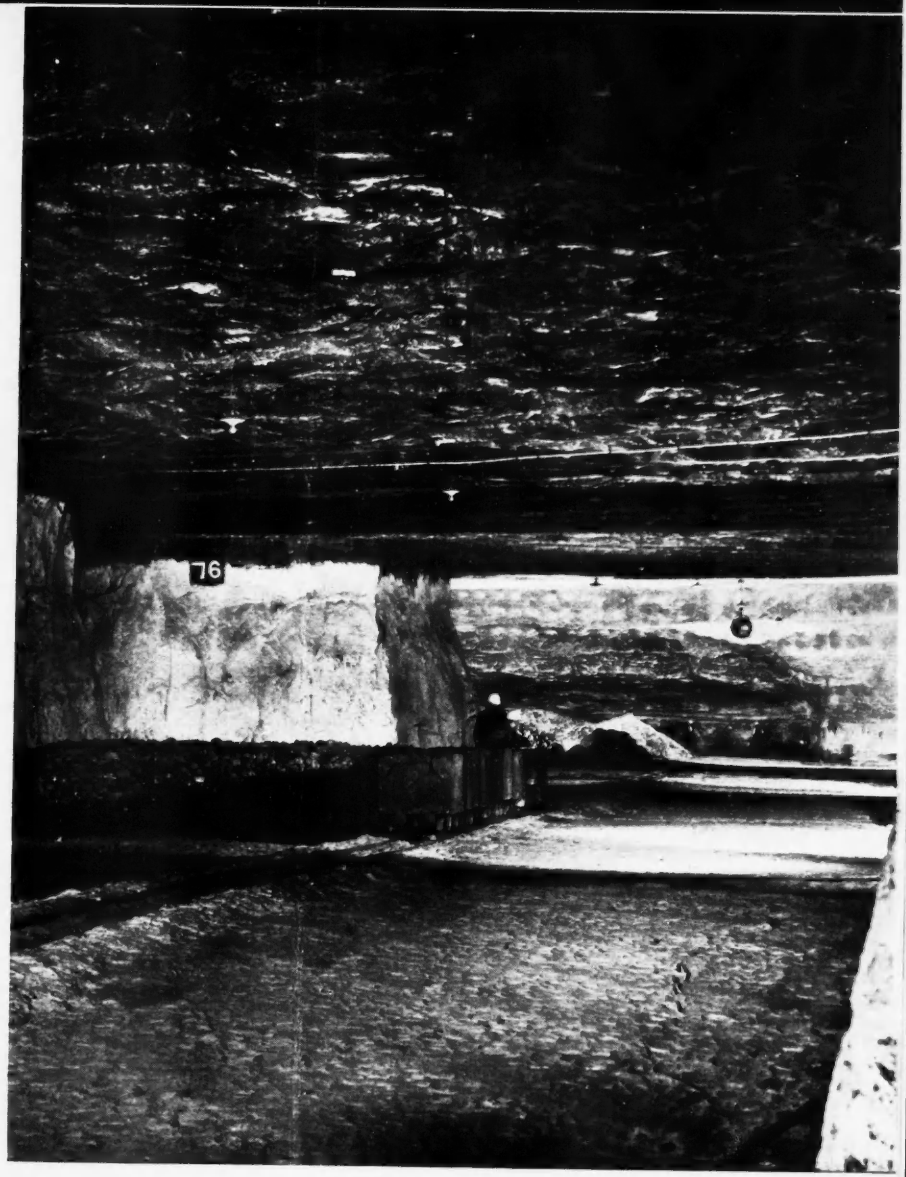
The Inventions of Friese-Greene
DENIS SEGALLER

Man's African Relatives
S. M. COLE, F.G.S.

Science Education in Russia
WILLIAM E. DICK, B.Sc., F.L.S.

Sodium Chloride: The Salt of Life
J. A. PARSONS

The British Association



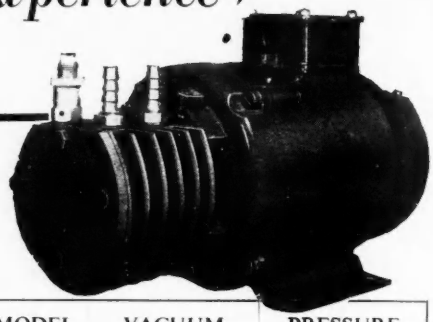
Britain's only working salt mine, at Winsford, Cheshire. I.C.I. photo.

UNIVERSITY OF MICHIGAN
PERIODICAL READING ROOM

NOVEMBER
1951
1/6

MINIATURE
VACUUM and COMPRESSOR PUMPS

Built on practical experience



These miniature combined vacuum and pressure pumps have been developed following extensive experience with our famous Type IV (RB.4) in use throughout the world.
Applications for these miniature pumps include:— Filtration . . . Distillation . . . Surgery . . . Bottle filling . . . Printing frames . . . Paper lifting . . . Paper handling . . . Aerating . . . Glass blowing, etc.

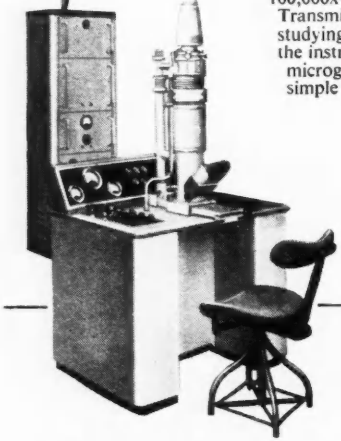
MODEL	VACUUM		PRESSURE	
	cm. Hg.	in. Hg.	lb./sq. in.	Kg./sq. in.
RB/FO	25·0	20	8	0·56
RB/FI	12·5	25	15	1·05

W. EDWARDS & CO. (LONDON) LTD.
LOWER SYDENHAM · LONDON S·E·26

. . . For better vacuum service
30 YEARS VACUUM EXPERIENCE

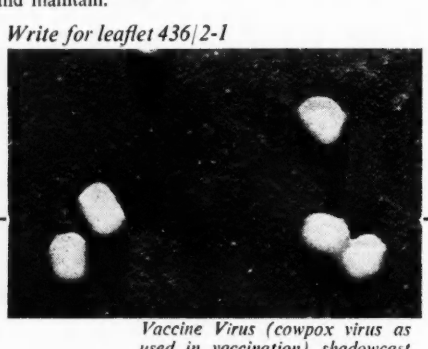
Telephone : SYDenham 70267 (8 lines)
Telegrams : Edcohivac, Souphone, London

The electron beam takes over . . . .



. . . when the optical microscope has reached its limit of resolution. The shorter wavelengths of electrons using accelerating voltages between 25/100 kV permits a resolution about 100 times less than that of the optical microscope to be attained
The guaranteed resolution of the E.M.3 is better than 50 A.U. and the instrumental magnification—continuously variable between 600x and 100,000x—enables the fullest utilisation of this high resolution.
Transmission electron micro-diffraction is available and useful for studying possible artefacts in replica specimens. The depth of focus of the instrument is sufficient to cover the most rugged specimen. Stereo-micrographs can be taken. The equipment is of unit construction, simple to install and maintain.

Write for leaflet 436/2-1



Vaccine Virus (cowpox virus as used in vaccination) shadowcast with uranium. (x 29,500)

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, TRAFFORD PARK, MANCHESTER 17
Member of the A.E.I. group of companies

METROVICK E.M.3 *the* ELECTRON MICROSCOPE

C/E002

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

November, 1951 Vol. XII. No. 11

Editor WILLIAM E. DICK, B.Sc., F.L.S.
Editorial Office: 244 High Holborn, W.C. 1. Tel. Chancery 6518
Advertisement Office: 11a Kensington Church Street, London, W.8. Tel. Western 8857
All Subscriptions, Distribution and Business Communications to Jarrold & Sons Ltd., Norwich. Tel. Norwich 25261

The Progress of Science

A Scrap of White Paper

THE WHITE PAPER on Higher Technological Education (published on Sept. 20) is most disappointing, and one hopes that the Ministry of Education will take note of all the fundamental criticisms; it has aroused adverse criticisms which have been expressed by the various professional bodies of technologists and also by influential journals as widely different as *The Times* and the *Economist*. To be brief, it is to be hoped that the policy advanced in the White Paper is never implemented. The general view among informed people is that the White Paper represents a stillbirth that would best be forgotten.

It proposes the establishing of a Royal College of Technology, which would be in effect an 'invisible college' without any of the normal functions of a college and bearing no resemblance to, say, the Imperial College of Science and Technology, with which the Royal College of Technology would be inevitably confused. This Royal College, it is proposed, should approve short courses at technical colleges and confer an Associateship of the Royal College of Technology on students who pass the requisite examination. This Associateship would be approximately of the level of a B.Sc. degree, but of a very different standard from, say, the Associateship of the recognised professional bodies to which technologists—such as engineers and chemical engineers—now belong. There would be immediate confusion here between the Associateship conferred by the Royal College of Technology and the Associate Membership of the engineering institutions.

The muddled thinking which characterises the White Paper seems to have originated in the original draft report produced by a body known as the National Advisory Council on Education for Industry and Commerce. A hint of the confusion to come was conveyed in an extract from the speech of the National Advisory Council's chairman (made to the Council as long ago as December 16, 1949), which accompanied the draft report when it was sent to various interested parties who were invited to comment on these draft proposals for improving higher technological education. The chairman spoke about "the task of *clearing* their minds on the important issues involved," and it implied (though doubtless without intending to do so) that the originators of the draft report were not clear about the important issues when they started preparing the draft.

Since then, the critics of the draft and of the White Paper have even gone so far as to say that those who prepared the draft did not recognise which issues out of the many issues involved were the important ones.

The draft report dismissed the idea that a training in fundamental science is necessary for technologists, in spite of the fact that the finest British technologists working in the most advanced branches of technology are usually men who have had training to graduate level in fundamental science before proceeding to study some special branch of technology. At this stage the report appears to have become muddled as to the difference between *technicians* and *technologists*, and its recommendations from then onwards seem to be concerned not so much with the training of technologists but of technicians. Once the report had acquired this bias, it proceeds to concentrate upon the technical colleges as being the institutions best fitted to train technologists to serve "the industrial needs of their neighbourhoods." The university as a source of technologists is dismissed in these words: "*Whilst it is not disputed that the training in basic fundamental science given by the best university course is indispensable to the highest flight amongst technologists—the applied scientist or the engineer scientist—the number of such men employed in industry will always form a relatively small proportion of the total technological personnel required . . . the university course is not necessarily the most appropriate for the large number of other types of technologists needed by industry.*"

The draft report mentions three possible types of National Institutes that might make awards to men who have received an approved academic course in technology. First, there is a National Institute to award a Diploma in Technology—a Dip. Tech. This, the report suggests, would be a failure, and cites the inferior status of the Higher National Diploma in Engineering compared with that of the external degree of London University.

A second institute—a National Institute awarding a bachelor's degree in technology, a B. Tech.—is mentioned. This was advocated by Local Education Authorities. The

draft report claimed that this would quickly gain "parallel status with existing university qualifications." (Presumably the report meant to say that it would gain *comparable* status; the term "parallel status" is meaningless unless one alters the normal meaning of the two words from which it is compounded.)

Finally there is the third proposal—the Royal Institute (or Society) of Technology. This is the proposal which the draft report favoured, and now it has been given full and unqualified Government support in the White Paper.

The professional technological bodies are far more critical about the draft report of the National Advisory Council.

The Councils of the Institutions of Civil Engineers, Mechanical Engineers and Electrical Engineers jointly produced a statement setting out their comments on the plan.

This statement shows that the engineers were very fair and open-minded in their consideration of the draft report. They were sympathetic with many of the main *aims* of the National Advisory Council, and agreed with the following points: (*a*) the general status and standards of full-time courses and similar courses of comparable quality and duration in Technical Colleges need to be raised; (*b*) the achievement of the desired standards can be assisted by the creation of a suitable national award capable of gaining a prestige comparable with that normally accorded to University degrees; (*c*) a suitably constituted independent body with national scope is needed to undertake the control of the proposed examinations and awards. The three engineering Councils offered their co-operation in a general scheme of this kind. They did, however, suggest that "some of the proposals in the National Advisory Council scheme extend much further than is necessary to achieve its main objectives, and that this jeopardises rather than helps its prospects of success." They foresaw the possibility that the Royal Institute of Technology might trespass on the fields already covered by existing societies with consequent overlapping and confusion. "The proposed body should limit its functions to the establishment and development of standards, examinations and awards," said the engineers, and this point appears to have been accepted by the authors of the White Paper. The engineers stressed the need for the conferment of awards by the Royal Institute of Technology to be "in the hands solely of those professionally qualified to adjudicate"—which is of course the system which prevails when the engineering institutions confer their Membership and Associate Membership. The engineers considered that, to start with, the Royal Institute of Technology should concentrate on a 'first' award, with a standard that would be acceptable to universities as satisfying their entry conditions for higher degrees. The first award should be given only on the results of examination by the Royal Institute of Technology, and there should be no exemption from examination.

The engineers wanted a Royal *Council* of Technology, rather than a Royal *Institute*, and proposed that the first award should be called a "Royal Diploma in Technology" —R.Dip.Tech., which would avoid confusion with the Associate Membership awarded by the various professional bodies of technologists. The Royal Council should be governed by a body which would include up to 20 representatives of Technical Colleges and one representative from each of the universities of England and Wales. (Scottish education is, of course, not the concern of the Ministry of Education in London, and so Scotland remains outside this particular discussion.) In addition the governing body should have two representatives from each of the major professional institutions concerned with technology; that would mean about 24 men altogether, on a governing body comprising about 60 members in all. Assessors appointed by the appropriate Government Departments should be attached to the Council.

The comments of the Institution of Chemical Engineers were also very interesting. This institution recognised that the draft report showed a lack of understanding of the meaning of technology, and therefore went to some trouble to explain exactly what is meant by technologies, both primary and secondary. Primary technologies are ones in which one or more sciences are applied to a wide range of industries, and here the chemical engineers pointed out that several of these technologies have long been included in university faculties of engineering in Britain and abroad, and that long experience has shown that the univeristy faculties can provide a thoroughly adequate mental training, given the appropriate cultural and humanistic background. Secondary technologies have not received the same measure of attention, and hence agreement on methods of training is harder to achieve. The chemical engineers suggested that the problem of assigning a place to a secondary technology in the existing educational framework had been complicated *by confusing the needs of technicians with those of technologists*. It pointed out the risk that any system of training rigidly confined to the requirements of a single industry introduces—*the danger of producing technologists who lack the broad understanding of basic scientific principles and of their application which is so urgently needed by industry today*. The chemical engineers referred to the changes now occurring in the relative importance of the different industries, and said that "it is clearly desirable to have available a body of highly trained technologists with the breadth of vision and flexibility of outlook to enable them to transfer rapidly from one industry to another and to acquire with facility the special techniques involved in such employment."

This is one of the most crucial matters in modern technology, and the failure of Britain to recognise that this point is all-important is one of the major reasons why many British industries are technologically backward compared with those of certain other countries. The chemical engineers are quite right in advocating that higher education in the secondary technologies can best be dealt with by a system of postgraduate training following undergraduate courses in the appropriate primary technologies or pure sciences.

Taking the two sets of comments on the draft report together, one reaches the conclusion that the National Advisory Council on Education for Industry and Commerce failed to hit the target because they never really got down to first principles. In their oversimplified discussion of technology and technological education, in which the role of the *technologist* became confused with that of the *technician*, the Council could not hope to reach any valid conclusions. It must be recognised therefore that the White Paper on

JÖNS JAKOB BERZELIUS
(1779–1848)

Son of a poor priest, he practised first as an apothecary, and then as a doctor after obtaining a medical degree. He joined the staff of Stockholm's College of Surgery, which, thanks largely to his efforts, became the Carolinian Institute, which is today responsible for awarding the Nobel Prizes for medicine and physiology. His chemical researches at this Institute made him the most famous chemist of his time, and as permanent secretary to the Swedish Academy of Sciences, he corresponded with scientists all over the world.

higher technological education, based as it was on the Council's draft report, provides no basis for action, and indeed it would be dangerous to attempt to implement any of its recommendations. The Council's draft report and the White Paper need to be referred back to their originators, though it would certainly be better to scrap both documents and make a fresh start. This particular and most important problem of higher technological education requires urgent solution, but it is quite certain that the White Paper policy does not offer the kind of solution acceptable to those who know most about technology—the practical technological experts who have already expressed their views perfectly clearly through the institutions of civil, mechanical, electrical and chemical engineering which represent the majority of Britain's technologists.

Berzelius, Inventor of 'Protein'

THE main source of information upon which the writers of the history of science have relied is what we commonly call 'the scientific literature'—that is, the journals in which the results of original scientific research are recorded, and the text-books which survey and summarise and generalise from what their authors consider to be the most important work done within the subject and the period under review. The scientific literature is naturally of supreme importance to the historian of science, but many points of great interest and great significance will be missed if he relies solely upon that source and neglects the huge mass of other material that is available. This moral emerges from the letter of Sir Harold Hartley about the origin of the word *protein* published recently in *Nature* (1951, Vol. 168, No. 4267, p. 244). For a long time it has been accepted that the term was coined by the Dutch chemist Mulder in a paper entitled "Sur la composition de quelques substances animales" which appeared in the monthly issue of the *Bulletin des Sciences physiques et naturelles en Néerlande* dated July 30, 1838. The term which derived from the Greek word πρωτειος meaning primary, holding first place, caught on and was soon widely used by chemists. It now seems quite certain that it was not Mulder but the great Swedish chemist Berzelius who invented the word *protein*, for it occurs in

a letter dated July 10, 1838, which Berzelius wrote to Mulder.*

As the years go by and the history of chemistry proceeds to be examined more and more closely, appreciation of the importance of the contributions he made to scientific thought grows. The deeper one delves into chemical history, the more one is impressed by the quality of Berzelius's research work, and by the calibre and originality of his theorising. He was considered a giant by his contemporaries, and the modern chemist takes the same view.

Jöns Jakob Berzelius lived from 1779 to 1848. In Sweden he had been preceded by Scheele (1742–1786) and Bergman (1735–1784). Bergman was among those who realised that something better than the then conventional symbols and nomenclature which cluttered up chemical writings was needed if chemists were ever going to be able to think clearly about their observations and produce the kind of far-sighted hypotheses which are so essential to the progress of science. The symbols used at that time were indeed barbarous, being hangovers from the period when the alchemists used mysterious hieroglyphics partly to prevent others learning their secrets, and partly to cover up their lack of real knowledge. The nomenclature of chemistry was crude in the extreme; it wreaked of "the language of the kitchen", to use the words of J. B. Dumas, being littered with dozens of terms like *butter of zinc* and *butter of arsenic*. Bergman and G. de Morveau improved the system of naming chemical compounds, and a great stride forward came when Lavoisier dealt the death-blow to the phlogiston theory and put chemists on the right road to the kind of nomenclature which was needed before further progress could be made.

Berzelius assimilated all that was useful in the writings of Lavoisier, and he also accepted Dalton's atomic theory. All important though that theory was to the future development of chemistry, it was in serious danger of stultifying for two reasons: firstly because the theory did not make the modern distinction between atoms and molecules; secondly, Dalton's symbols for elements were so clumsy that they obscured what the chemical composition of any given compound was. Avogadro corrected the first fault, though a long time was to elapse before his ideas were to gain general acceptance. It was Berzelius who broke the deadlock that existed with regard to symbols, and this he did by introducing the most familiar system whereby an atom of an element is represented in a chemical formula by the initial letter of the element; thus *Au* for gold, *Ag* for silver, and so on. To Berzelius the formula for water was H2O. (It was the Germans Liebig and Poggendorff who introduced the use of *subscript* figures, whereby the formula for water became H_2O, for instance.)

One of his great contemporaries was Volta, professor of physics at Pavia and inventor of the 'Voltaic pile'. Berzelius saw that this could be a mighty weapon in the chemical laboratory, and with his oldest half-brother, Lars Ekmarck, he did many experiments on voltaic electricity. "His thesis for his medical degree was on the action of electricity on organic bodies," says Bernard Jaffe in *Crucibles: The Story of Chemistry*. In the next year he published a paper on the splitting of chemical compounds by voltaic electricity, and he put forward an electrolytic theory according to which metals always went to the negative pole and non-metals to the positive pole. In Britain the importance of the voltaic pile was recognised by William Nicholson and Carlisle, and Davy used electrolysis to isolate sodium and potassium. In Sweden, Berzelius and his colleague Pontin succeeded in obtaining barium and calcium amalgams (amalgams with mercury, that is) by this method, and it was Berzelius's method which Davy used to isolate calcium, magnesium, barium and strontium. The isolation of those elements won for Davy the medal of the French Academy of Sciences, but as Bernard Jaffe has said, there can be little doubt that Berzelius would have shared this prize had the Academy known that Davy's discoveries resulted from the previous work of Berzelius. But the incident caused no jealousy between Berzelius and Davy, and they remained friendly, and always ready to learn from each other. Thus we find that Berzelius, who had believed firmly that chlorine had a compound nature, immediately accepted Davy's findings in this matter; Davy had shown by electrolysis that hydrochloric acid was a compound containing nothing but hydrogen and chlorine, which destroyed the prevailing idea that this acid also contained oxygen, and Berzelius immediately proceeded to wipe the word 'oxymuriatic acid' from his vocabulary. When Berzelius visited England he made a point of calling on Davy, who later returned the compliment when he went to Sweden. Berzelius was to Davy "one of the great ornaments of the age".

Out of his electrolytic work came Berzelius's "dualistic theory of chemical combination", according to which salts are to be regarded as derived from a union of a basic (electropositive) oxide with an acidic (electronegative) oxide. This idea is not so very remote from the picture which the ionic theory proposed, although Berzelius's hypothesis was more or less completely rejected by the chemists who came immediately after him. But the concept of *radicals* which derived from Berzelius's dualistic theory was to play a very important part in the progress of chemistry.

Another great contribution made by Berzelius was the idea of *isomerism*, which arose out of the researches of his pupil Wöhler. The latter had analysed silver cyanate and found its formula to be AgCNO. Liebig, working in Gay-Lussac's laboratory in Paris, was studying silver fulminate and found that this quite different substance had the same formula as Wöhler's silver cyanate. Berzelius pondered over this fact, and then offered the right explanation for it. A different arrangement of the atoms within the molecule could lead to two compounds with the identical formula having quite different chemical and physical properties. The idea of *isomers* was thus born from Berzelius's consideration of this case, and the words *isomer* and *isomerism* were coined by him in this connexion.

It was soon after that Wöhler gave the world the startling discovery of the isomerism of ammonium cyanate and

* This letter contains the following passage: "*Or je présume que l'oxyde organique, qui est la base de la fibrine et de l'albumine (et auquel il faut donner un nom particulier p. ex. protéine) est composé d'un radical ternaire, combiné avec de l'oxygène dans quelqu'un de ses rapports simples que la nature inorganique nous présente.*" And later in the same letter: "*Le nom protéine que je vous propose pour l'oxyde organique de la fibrine et de l'albumine, je voulais le dériver de* πρωτειος *parce qu'il parait être la substance primitive ou principale de la nutrition animale que les plantes préparent pour les herbivores et que ceux-ci fournissent ensuite aux carnassiers.*"

urea. That is, he *synthesised* urea from ammonium cyanate —which meant that a vital substance could be produced from an inorganic substance. There is no need here to stress the importance of that discovery, beyond saying that it was necessary for the similarity between the chemistry of organic substances and the chemistry of inorganic substances to be established before real progress could be made in the science that deals with the analysis and synthesis of organic compounds.

Berzelius's investigation of atomic weights is an absolute classic of careful systematic research, and one of the most colossal tasks ever attempted by an individual chemist. The accuracy of his atomic weights is impressive even by modern standards.

Norway's Atomic Pile

THE 75TH ANNIVERSARY meeting of the American Chemical Society referred to in the last issue of DISCOVERY, was followed by an International Congress of Pure and Applied Chemistry which was attended by scientists from all over the world, a strong contingent of British chemists being present.

Among the subjects which were discussed by the congress were the practical matters of the atomic age, which now concern chemists and chemical engineers more than they do nuclear physicists. The participation of chemical experts in atomics pre-dates the bringing into operation by Fermi and his team of the first atomic pile in December 1941, and has steadily become more and more important until today the availability of top-rank chemists and chemical engineers has become the main limiting factor in atomic development. So it is not surprising that atomics was one focal point in the congress's proceedings.

It was announced at the meeting that an atomic pile at Kjeller, Norway, built jointly by the Norwegian and Netherlands governments, had come into operation and had been running successfully at a low power level for about a month. This means that Norway is the first of the smaller nations of Western Europe to have a nuclear energy plant within its own boundaries. Dr. Odd Dahl described the new reactor in a paper presented to the Nuclear Chemistry Section of the Congress. Only two other Western European nations—Great Britain and France—have nuclear reactors. Dr. Dahl, who is a research engineer of the Christian Michelsen Institute at Bergen, directed the construction of the Kjeller reactor for the government-sponsored Institute for Atomic Energy Studies at Oslo. Co-author of his report was Dr. Gunnar Randers, who is director of this institute.

Holland supplied the uranium for the pile, and the two nations, through their national research councils, are exercising joint supervision over its operation, Dr. Dahl explained. They will likewise share the information obtained.

The Kjeller pile is a heavy-water pile. It was explained that the enterprise was based on heavy water instead of graphite because of the great difficulty of making graphite of the extreme purity required. Heavy water does in fact carry the advantage that the neutron density in a heavy-water reactor is about ten times as great as in a graphite pile, providing a much more powerful research tool. This point is recognised by the Americans, and development of heavy-water piles in the U.S.A. is proceeding apace.

One of the most significant aspects of the completion of the pile in Norway, Dr. Dahl noted, is the proof it provides that a small nation can build a reactor *at reasonable cost* with the knowledge available generally to chemists and physicists.

Dr. Dahl stressed that the Kjeller pile is too small ever to turn out enough plutonium to enable Norway to make an atomic bomb, although it will be able to make a 'fair amount' of plutonium after a while. Rather, he explained the reactor will be employed in experimental work, with the production of radio-isotopes for use in medicine, industry and research an important product. The isotopes will be particularly useful because many of these materials disintegrate too fast to be imported from abroad.

Looking far into the future, Dr. Dahl spoke of the day when Norway will have made enough progress in the nuclear energy field to be able to provide atomic power for much of her industry and also her merchant fleet, which is at present outranked only by those of the United States and Great Britain. As a nation which must import both petroleum and coal, Norway has far greater need of atomic power than has the United States, Dr. Dahl pointed out.

The Kjeller pile was given a trial run at the beginning of August, and Dr. Dahl said these tests are still in progress with the power at about 100 kilowatts. It is expected that this level will be raised later to about 300 kilowatts.

Another paper to the Nuclear Chemistry Section was given by Dr. Kenneth S. Pitzer of the University of California, and a former research director of the U.S. Atomic Energy Commission, who said *chemical* obstacles were the chief obstacles to the commercial development of atomic energy. This paper, of which Spofford C. English of the Atomic Energy Commission (A.E.C.) in Washington, was co-author, stated that the economic future of atomic energy is principally in the hands of chemists.

As an example of the chemical problems to be overcome in the production of atomic power for industry, Dr. Pitzer cited the development of a suitable metal for construction of the pipes which conduct cooling fluids to control the operating temperature of the pile. At the relatively low temperatures used in the present atomic piles for the production of plutonium, aluminium is satisfactory for making the cooling coils, but at the high temperatures necessary for power production, chemical corrosion problems are immediately encountered. It was necessary to find a material to withstand the pressure and to resist chemical corrosion at the high temperature; moreover the material must not absorb neutrons from the pile. Dr. Pitzer said. A specially purified zirconium had been found to be a satisfactory material for a slow-neutron pile, he added.

Dr. Paul C. Aebersold, chief of the isotopes division of the U.S. Atomic Energy Commission, Oak Ridge, Tennessee, described a method whereby traces of materials too small to be detected by other means could be detected by "atomic analysis". The new technique can be used to identify a large number of the chemical elements, some of which have been very difficult to detect by previous methods of analysis. "Activation analysis," as Dr. Aebersold calls the new system, is particularly useful when unknown substances are mixed with other materials which interfere with conventional testing methods.

When an unidentified material is placed in the atomic

pile, its chemical elements become radioactive, and each element gives off its own specific kind of radiation, Dr. Aebersold, explained. On removing the sample from the pile, a scientist can identify the elements present in it by measuring its radiation characteristics. The quantity of each element present can also be determined. The method is very sensitive. The sensitivity varies with different elements and depends on the strength of radiation in the atomic pile and on what other materials are present in the sample.

A One-sided Atomic Arms Race

PRESIDENT TRUMAN'S announcement of October 3 that the Russians had carried out a further atomic-bomb test came as no real surprise. In view of the fact that the Russians tested their first bomb over two years ago, the only surprise was that it took so long for them to arrange a second test.

Commenting on the first explosion (*see* DISCOVERY, November, 1949), we stressed the necessity of treating the official Russian statement about it solely as a piece of propaganda that had been designed to mislead opinion both inside and outside Russia. The Russians were claiming that the atomic explosion was connected with big civil engineering projects; it was nothing more, they said, than the use of "the latest technical means for routine blasting operations". This claim was intended to convey the impression that Russia had such huge stocks of fissile materials that they could afford to use them instead of dynamite. But the light-hearted and extravagant nature of this idea made the Russian claim immediately suspect. Our view that the claim was pure fiction is now confirmed by Stalin himself.

Pravda of October 6, 1951, reported an interview with Stalin, in the course of which he stated categorically that "one of the types of atom bombs" was recently tested in Russia. In other words, Stalin made no attempt to disguise the atom-bomb explosion as a civil engineering job; this time it was a military bomb, a part of what Stalin called "the plan for the defence of our country from attack by the Anglo-American aggressive bloc."

Stalin did, however, play one card which, though it may have looked like a trump card from where he stood fn the Kremlin, had all the appearances of an ace of propaganda to everyone outside Russia. He spoke of testing "atom bombs of various calibres", and the West was clearly intended to draw the conclusion that the Russian armoury is bristling with a fearsome variety of atomic weapons. But this propaganda line is no more convincing than the old Russian line about moving mountains with atomic explosives. Propaganda cannot neutralise the superiority of the Americans in all matters atomic. Beria, the member of the Politburo who directs the Russian atomic project with one hand and supplies slave labour for it with the other hand—the hand that controls the Russian Secret Police—must realise this. There is no doubt that Stalin's story is but a paraphrased chip off the recent statements made by Gordon Dean, Chairman of the U.S. Atomic Energy Commission.

Gordon Dean has spoken of "dozens of different types and kinds of special purpose atomic weapons" now under development in the U.S.A. "We are working towards a situation where we will have atomic weapons in almost as complete a variety as we do conventional ones, and situations where we can use them in the same way. This would include artillery shells, guided missiles, torpedoes, rockets, and bombs for ground-support aircraft among others, and it would include big ones for big situations and little ones —and this is important—for little situations," Mr. Dean told a Congressional sub-committee on September 27—the date is significant because it ante-dates Stalin's *Pravda* interview by a time sufficient to enable the Russian propaganda machine to steal a clap or two of Mr. Dean's atomic thunder.

It is now certain that it will not be long before the U.S. Army has tactical atomic weapons. This fact is brought home forcibly by the announcement that the next atomic tests carried out at the Atomic Energy Commission's proving grounds in Nevada will be witnessed by some 5000 soldiers, who will be "indoctrinated" in the problems that arise when an atom bomb explodes near a formation of troops.

Waste of Coal *v.* Waste of Words

THE falling of the first autumn leaves starts the discussion on winter pastimes. The newest of these is "beating the fuel crisis" and it receives all the enthusiasm an Englishman reserves for lost causes. Even distinguished scientists join in, not always with as much credit to their heads as to their hearts. We no longer get the cheer-leaders' simple exhortations—"Turn off that light", "Insulate your hot-water tank", "Put two dishes in the oven not one". The light is off or dim, the hot-water has run cold and the cooker ceases to function as the electricity supply fails.

What we get today is a new approach, involving the re-discovery of Carnot's cycle once a week. Once a month Carnot is stood on his head to demonstrate that heat pumps are two or three hundred per cent efficient. Alternatively, we travel all the way back to Rumford to discover that excess air in a parlour-fire does no good. Personally, we vote for Carnot's cycle—except in so far as it can give rise to a vicious cycle. You can't make it work for you unless you are able to use a good deal of iron, and hence coal, to make a start.* District-heating schemes and heat pumps take some years to pay off, and the immediate diversion of such resources is what can't be spared. We need the kind of installation which pays for itself by the coal it saves in six months. If we accept the statement of Dr. J. Bronowski at the recent Smoke Abatement Conference, the answer is at hand. "We talk grandly of harnessing the tides on the Severn at a cost of £100 millions; but half that sum would modernise enough house and factory grates to save 20 million tons of coal a year." We regret that none of the political parties will put it in their manifesto before October 25th. It is the first investment at 200% to be put on the market since the South Sea Bubble.

We have only one misgiving. £50 millions spread over 15 million households in this country would mean just over £3 per grate. We have not yet met a builder who will say "Good morning" politely for that sum, let alone come into the house and do a job.

* Roughly two tons of coal are needed to make a ton of iron or steel.

Radioactive Dust as a Weapon

PROF. HANS THIRRING*

AN AMERICAN REPORT on recent experiments with the atom bomb stated that radioactive poisoning in the target area proved to be less than had been anticipated, so that rescue personnel might enter the area of the explosion fairly soon without being endangered by radioactive rays. A statement like that might lead us to underestimate the dangers of radioactive weapons in an atomic war. The vast majority of newspaper readers are scarcely aware of the fact that apart from the atom bomb—to which the quoted report refers—a quite different sort of atomic warfare is now technically feasible, the nature of which has never been made fully known to the public.

Let me shortly explain the basic facts. In the atom bomb as well as in atomic power piles now being built in America, and probably elsewhere, the process which generates the energy is the fission of the nuclei of heavy atoms like uranium 235. The fragments produced by the nuclear fission are the nuclei of radioactive isotopes. Since they result from the splitting of a heavy nucleus, these isotopes have medium atomic weights; they are isotopes of elements like iodine, strontium, barium and so on. But all these fission products are radioactive, emitting beta and gamma rays. Hence the atom bomb in the act of explosion, and any atomic power pile while in action, are powerful sources of radioactive material.

When an atom bomb explodes high above the ground the greater part of the radioactive fission products is swept up by the rising mushroom of hot gases into the upper atmosphere, where it is soon sufficiently dispersed and ceases to be of real danger. Only a very minute fraction of the radioactive material is blown towards the ground where it causes some slight contamination.

But as we have seen, quite independently of the bomb, radioactive fission products are also generated in atomic piles which are now widely used for the production of plutonium, and will be still more extensively used in the future as power plants. The amount of radioactive matter produced by them is directly proportional to the power of the pile. These fission products have to be removed from the pile at certain time intervals, in much the same way as in an ordinary steam plant the ash has to be removed. But with this important difference: whereas ash is quite a harmless material and may be deposited anywhere, radioactive isotopes in any large quantity are very dangerous. Hence provision has to be made to bury them in very deep pits dug especially for the purpose.

In these days of cold war and rearmament, however, the possibility must be taken into consideration that the military authorities of countries possessing atomic piles will store their dangerous by-products with the intention of using them to make enemy cities or industrial centres uninhabitable. This could be done by impregnating fine-grained sand with, for instance, the salts of radioactive iodine and strontium, and by delivering this radioactive dust by means of aeroplanes, rockets or guided missiles pre-arranged to release the dust at calculated heights over the target area. The powder falling down slowly may cover many square miles with a practically invisible layer of dust which emits radioactive radiation strong enough to inflict within a few weeks a lethal dose of radiation on everyone remaining in the contaminated zone. The strategic value of such a weapon depends simply upon the size of the area which could be effectively contaminated. Imaginative but incompetent writers have been toying with the idea of drawing a poison barrier across Eastern Europe right down from the White Sea to the Black Sea, to cut the European part of the Soviet Union from Siberia. Is anything like that possible? In a paper published in an Austrian journal of physics in 1948 I made some numerical estimates of the amount of radioactive contamination which can be deliberately caused by applying the fission products of atomic reaction. In making such calculations one has to consider the fact that, when producing and storing over an unlimited period, the stock of radioactive material does not increase proportionally to production time, because the radioactive material begins to decay the moment it is formed. When by switching off the reactor production is stopped, the stock of radioactive material will decrease by nuclear disintegration and accompanying transmutation into non-active isotopes. The relevant quantity is therefore not the amount of material produced *daily* but the *equilibrium* which will be reached when further production is balanced by the decay of the material. The whole set of radioactive elements produced in a reactor is a mixture of about 300 isotopes. These isotopes have quite different lifetimes, ranging from a fraction of a second to several years. Neglecting those which, because of their quick decay, have too short a life for military use, the calculation shows that a uranium reactor generates along with each kilowatt of its power an *equilibrium* quantity of sufficiently long-lived isotopes whose radioactivity corresponds roughly to one pound of radium.

This is a strikingly high figure in view of the facts that the quantity of all the radium in the world used so far for scientific or medical purposes scarcely exceeds a few pounds and that the power of modern big plants is not one kilowatt but well over a 100,000 kilowatts. The activity of the by-products of an atomic power plant will, therefore, correspond to that of *50 tons of radium—or fifty million grams*. Each single gram of radium is a strong source of radiation which must be handled very carefully, and is nowadays stored, when not in use, in the strong rooms of the hospitals in order to avoid damage to the personnel.

Further calculations give the following result: if in a few decades only 10% of the power consumed in the U.S.A. is generated by atomic piles, the stock of radioactive material which may be used for contamination of an enemy country will suffice for making an area of about 3000 square miles uninhabitable. This figure is the same

* Prof. Thirring is an Austrian Scientist on the staff of Vienna University. His book *Die Geschichte der Atom bombe* (see *Discovery* August 1947, p. 227), revealed the story of the German atom-bomb project, and drew attention to the possibility of producing a hydrogen bomb.

regardless of what specific type of atomic plant is used. Any other nation, including, of course, Russia, will obtain the same amount of radioactive material if the same amount of power is generated in atomic piles. This figure has been calculated on the assumption that a district is to be considered as uninhabitable if a man living in this district received a lethal dose of radiation within four weeks.

Comparing this result with geographical data we are led to the conclusion that the establishment of a poison belt across Eastern Europe, strong enough to prevent the supply of arms and troops to and from Siberia, is out of the question. On the other hand, the given quantity of radioactive isotopes would suffice to contaminate all the big cities of Europe.

A contamination of this kind could be administered in such a way that the lethal dose of radiation would be reached only after *a month's stay* in the radioactive area, whereas no effects on the human body would be caused within a few hours or even a day. In view of this fact, it has been pointed out that, although any war is a crime today, this specific kind of warfare would be relatively humane compared with burning people alive with flame throwers or blowing them to pieces with shells and bombs. Not a single human being would die if the contaminated area were evacuated within 24 hours and not a single building would be damaged. Hence by wisely and cautiously using radioactive contamination and by warning the enemy in time, a nation having a sufficient stock of radioactive isotopes along with the necessary aircraft might force its enemy to stop the war without firing one gun, without killing a single person or destroying one house.

I do not mean, however, to advocate radioactive warfare. *No war at all*—that is the only answer to the threats of modern science. The fission products of uranium are not the only radioactive isotopes which can be artificially produced by modern atomic physics. Practically all the elements can be turned into radioactive matter by nuclear transmutation caused by the neutrons released in an atomic explosion. Tentative estimates have shown that, by exploding a very large hydrogen bomb covered by a thick cobalt layer, an amount of radioactive cobalt could be produced which would be sufficient to bring death to all the organic life on earth.

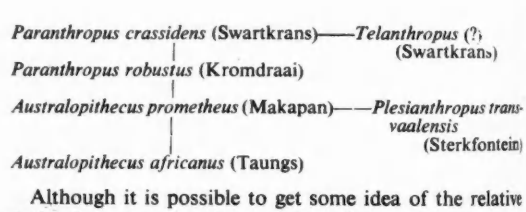
At that stage of technical development it will be no use trying to stop further research in the atomic field or to ban a specific sort of weapon. What we need is to abandon old-fashioned ideas and attitudes stemming from the pre-atomic age, as, for instance, the childish pride of frightening one's neighbour by military superiority. Let us foster the realisation of the need for international co-operation under the rule and order of universal law—then we need not bother about the dangers of the atom.

MAN'S AFRICAN RELATIVES—*continued from p. 353*

Upper Pliocene, to judge from the contemporary fauna. This makes it impossible for the Australopithecinae to have been ancestral to man, and they are now regarded as representing yet another of the side branches of man's family tree which have proved unsuccessful and have therefore withered away. They left no descendants so far as we know. As in the case of *Proconsul*, their unspecialised characteristics are probably typical of the ancestral form of both man and the anthropoid apes. Man's own particular specialisations (e.g. the great development of the brain and reduction of the jaw) are less exaggerated than the extreme specialisations of modern anthropoids.

On the whole, over-specialised types tend to become extinct far sooner than unspecialised forms: this happened to the once-flourishing dinosaurs, and it happened to the slouching Neanderthal race. Little tarsiers and lemurs, on the other hand, have remained practically unchanged since Mesozoic times. Today the gorilla seems doomed to early extinction owing to its extreme specialisation; it is too heavy for life in the trees and is not well adapted for walking on the ground; its long arms and short hind legs make progression on all fours uncomfortable, yet it is too heavy to retain an upright posture for long. It is evident that the gap between the Australopithecinae and *Homo* is less wide than the chasm which separates them from the great apes of today.

In conclusion, the *relative* and still tentative dating of the South African apes may be set out as follows, the earliest being at the bottom. (The site where they were found is given in brackets):


Paranthropus crassidens (Swartkrans)——*Telanthropus* (?) (Swartkrans)
Paranthropus robustus (Kromdraai)
Australopithecus prometheus (Makapan)——*Plesianthropus transvaalensis* (Sterkfontein)
Australopithecus africanus (Taungs)

Although it is possible to get some idea of the relative dating by comparing the associated fauna, the exact geological age of the fossils is very hard to determine owing to the unstratified nature of the limestone in which these fossils occur. Some idea of the difficulties involved may be gained from the following passage (about Sterkfontein) from Dr. Broom: "The caves are large and may have been used by carnivores as lairs for many thousands, perhaps many tens of thousands, of years, so that the deposits in one part of the cave may be of very different age from deposits only a dozen yards away. For example, closely associated with the type skull of *Plesianthropus* is a small baboon which has been called *Parapapio broomi* by Dr. Trevor Jones; but at a slightly higher level not 30 yards away has been found a larger, and certainly different, species *Parapapio whitei*. Then there are other caves only about a hundred yards away where a number of mammals have been found which do not occur in the *Plesianthropus* cave. . . . Some day it may be possible to give all the horizons of the mammals found, but it will be a matter of great difficulty and I do not think anyone will be able to do it for years to come." To add to the difficulties, there are only a few genera amongst the associated fauna which occur in other parts of the world, so comparisons are mostly practically impossible.

The Inventions of Friese-Greene

DENIS SEGALLER

PROBABLY not one cinemagoer in a hundred, perhaps less than one in a thousand, gives a moment's thought to the basic mechanism of the films they see—that which creates on the screen the illusion of movement. Some people, perhaps, realise vaguely that what they are seeing is a succession of static 'magic-lantern slides', but for most it goes no further than that. Yet it is true that if time could be slowed down for us, as it was in H. G. Wells' *The New Accelerator*, a film would appear as an unbearably long presentation of perfectly still photographs on the screen, each one being shown for the same length of time, each slightly different from the previous one and separated from it by an equal duration of total darkness. The basic principle of cinematography is the same in the camera that takes the pictures and in the projector that shows them. In the former, a rapid succession of 'snapshots' is taken by means of a mechanism which pulls a long roll of sensitised film past the lens in a series of jerks, the exposure being made while the film is held still between jerks. A shutter driven by the same mechanism rotates so as to cut off all light while the film is pulled down sufficiently for the next picture to be taken without overlapping the previous one.

In the projector a positive print from the photographic negative is run through by a similar device, the shutter again cutting all light off from the light-source while the film is jerked down, so that one picture is replaced by the next.

If the pictures follow one another at any speed faster than 12 per second, the eye sees no flickering; one picture blends smoothly into the next, and the illusion of movement is created. The basic mechanism, then, is an intermittent drive to the film coupled to a rotating shutter.

Who invented cinematography? This is not unlike asking who invented the motor-car. The answer in each case is that it was the culmination of many men's work and ideas. Americans may swear that Edison invented the cinematograph; Frenchmen may claim the honour for Lumière.

But there is solid evidence that the basic principle described above—a long strip or roll of photographic material driven intermittently past a lens, and with a coupled rotating shutter—was first clearly grasped, successfully carried out, and patented, by an Englishman, William Friese-Greene.

Friese-Greene's first patent, granted in 1890, is for a camera embodying "the combination of an intermittently opening shutter with means for giving an intermittent motion to a sensitised strip, the whole being actuated from a common shaft or its equivalent, in such a manner that the opening of the shutter takes place during a rest period of the strip". So far no earlier patent for this principle has come to light anywhere in the world, and this alone would entitle Friese-Greene to be styled the father of cinematography. He did in fact take and show moving pictures in 1889 which were substantially as we know them today; and while, in the camera of this first patent of 1890, the film was driven by friction against a drum mounted on a cam device, he later developed and patented a camera in which the film was perforated down both sides and driven by a toothed wheel. Thus again, he pioneered in a fundamental feature of modern films—sprocket-holes.

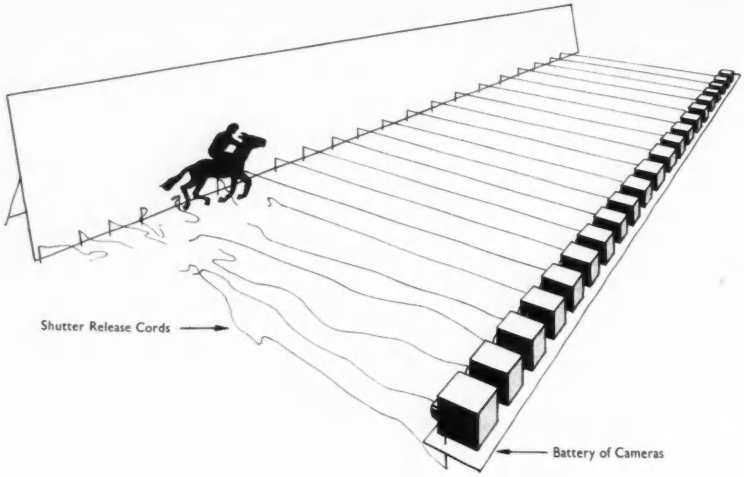
Friese-Greene was a truly remarkable man. Having become thoroughly obsessed and fascinated with photography, he wanted photographs that copied nature as closely as possible in every way. He wanted, first and foremost, to make pictures that moved; but he also wanted two other attributes—the three-dimensional or 'solid' effect, as opposed to 'flat' pictures, and natural colour. Those first moving pictures made in 1889 were taken by the camera of the 1890 patent, and this camera also embodied twin lenses, separated by 2½ inches—the distance between the human eyes. These lenses took two slightly different views of the subject for each frame of the film, the two being photographed side by side on film roughly 6 inches wide, as against the 35 mm. of today. The purpose here was to produce a stereoscopic or three-dimensional effect; unfortunately, however, although Friese-Greene was again the first man to associate stereoscopic and cinematograph mechanism, he does not appear to have fully grasped the implications of projecting such films stereoscopically on to a large screen so that every member of the audience would see only the 'left' image with the left eye and conversely for the right. Here again, his patent for stereoscopic motion pictures (taken out in 1893) has world priority, and the process was probably successful in so far as the two images could be projected side by side and viewed through stereoscopes, Victorian pattern, one per head of the audience. But his ideas in this direction never produced practical results.

His Colour Films

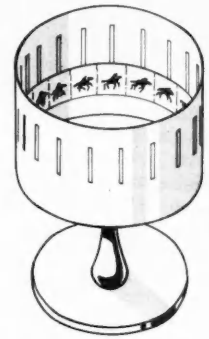
In the field of colour cinematography Friese-Greene was more successful; here he seems to have had a sound grasp of the physiological factors relating to colour vision and colour reproduction. The basic principle of resolving the subject into three photographs recording respectively its light and shade in terms of red, green and blue light and then recombining these three photographs each in light of its own colour in superposition on a screen, had been realised by Clerk Maxwell and demonstrated by him in 1855. Friese-Greene's first patent in this direction was taken out in 1893 and was designed to produce 'artificial scenery', in the form of moving backcloths, for theatres; the method he describes appears to be perfectly correct in principle. But his more significant work in colour cinematography came later, in 1898 and onwards. In that year he patented a mechanism using a rotating filter divided into red, green and blue sectors. Opinions vary as to the quality of the result: but the method certainly yielded the first effective motion picture in colour ever to be made.

Friese-Greene pursued his work on colour more persistently than any of his other ideas; he experimented with and patented several 'two-colour' systems which were compromises in the interests of mechanical and optical

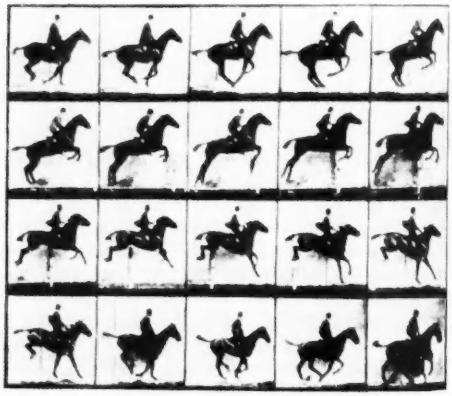
The Evolution of



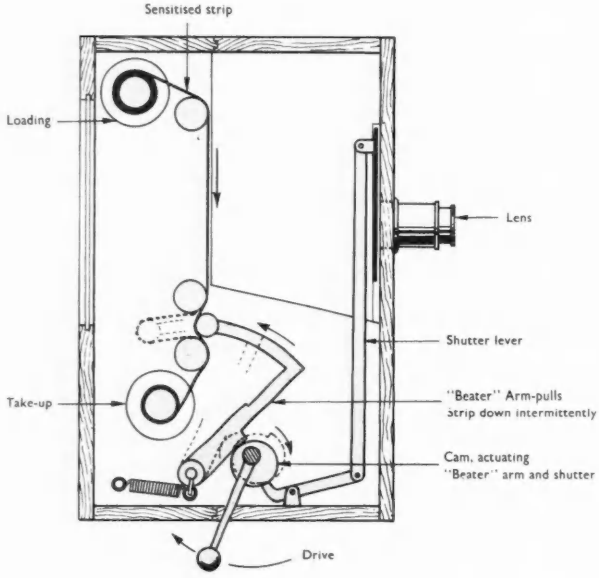
THE MUYBRIDGE EXPERIMENT



THE ZOETROPE



1872. Edward Muybridge, using a battery of "still" cameras, produced a series of pictures of the moving horse. To add motion, the pictures could be mounted on an instrument such as the Zoetrope.

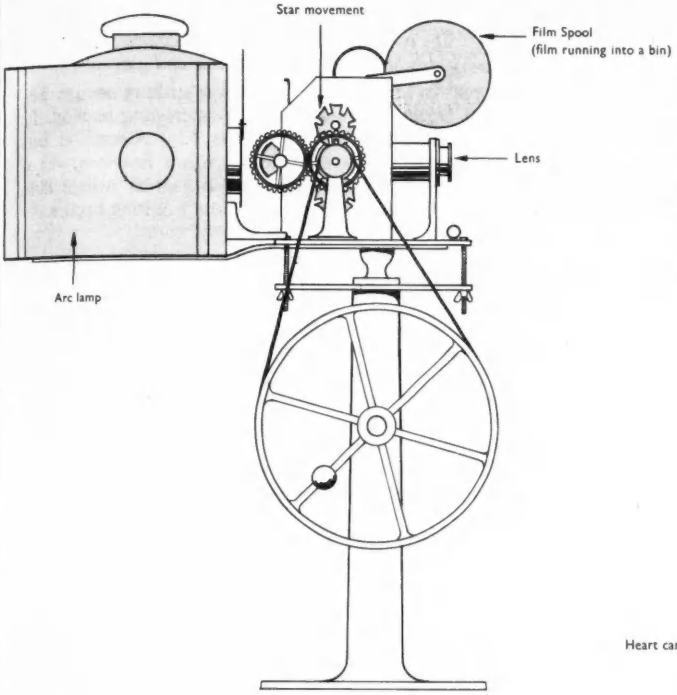


A FRIESE-GREENE CAMERA OF 1890

Using unperforated film and a "beater" movement for obtaining intermittent film motion.

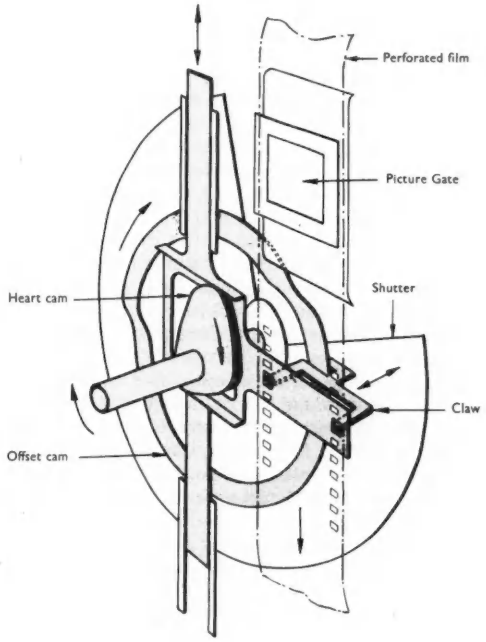
1890. Friese-Greene patented his invention using one single-lens camera to obtain a series of pictures in rapid succession upon a moving sensitised strip. The camera embodied an intermittent film motion coupled to a shutter which cut off the light to the strip during its period of motion past the lens. The unperforated strip was pulled through in jerks by the "beater" arm carrying a roller; a cam returned the arm to the rest position, allowing the strip to remain stationary while receiving the picture.

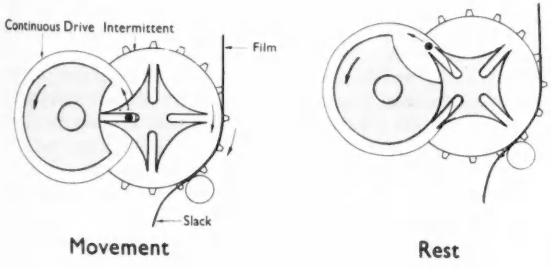
of the Cinema



1896. By now, perforated celluloid film had come to stay, exerting a powerful influence on the design of motion picture apparatus. Robert Paul's "Animatograph", the first commercial projector, using arc lamp illumination and a star or Geneva film-traction mechanism, was installed in the Alhambra, Leicester Square, projecting 35 mm. film on to a large screen. This machine was the forerunner of the modern projector.

1896 THE ROBERT PAUL "ANIMATOGRAPH"





MALTESE CROSS OR GENEVA MOVEMENT —FOR PROJECTORS

LUMIÈRE CAM MOTION FOR CAMERAS

1898 onwards. Two important mechanical principles, both of sound and well-tried design, are with us still. The Lumière Cam was a popular and accurate camera movement for many years, and provided a means of filming a great number of motion pictures; while in the field of projection the "Geneva" or "Maltese Cross" has held its own and is still the main form of projector mechanism in use today.

simplicity. He experimented with staining alternate frames of the film red and green. His ingenuity in this field was endless, and he kept abreast and probably ahead of all similar inventors of his time.

Friese-Greene's inventive capacity was enormous, but he was a child in legal and financial matters, and the worst possible business man. It has been stated that he never earned a penny from any of his inventions relating to motion pictures. The film industry have, however, paid tribute to his pioneer work in a monument to his memory designed by Sir Edwin Lutyens bearing the inscription:

WILLIAM FRIESE-GREEN
The inventor of kinematography
His genius bestowed upon humanity
The boon of commercial cinematography
of which he was the first inventor and patentee.

His part in the genesis of films was striking enough: his life story as a whole makes highly interesting reading. It has been admirably told by Miss Ray Allister in her biography *Friese-Greene: Close-up of an Inventor*, which has now been dramatised in the Festival of Britain film called *The Magic Box*, directed by the Boulting brothers.

THE PROBLEMS OF NATURE PROTECTION

AN expert conference held under the auspices of the International Union for the Protection of Nature met at the Hague from September 19 to 22. It was attended by over 120 delegates from sixteen countries. The two main themes of the Conference were (1) the problems of maintaining rural landscape as a habitat for flora and fauna in densely populated countries, and (2) the management of nature reserves. The conference made it obvious that much more research has to be done into many problems, and that the solution of these problems may overturn many cherished 'common sense' ideas.

Without the recently established Nature Conservancy, which can act as an agent and patron of such research, the British delegation to the Conference would have been severely handicapped. The British public is still largely ignorant of what the Nature Conservancy has been doing. It was therefore good to learn during the course of the discussions at the Hague about some of the projects on which the Conservancy has embarked. It appears that the Conservancy has already interested itself in the problems of coastal protection, peat-cover, the vegetation of spoil-heaps, the effect of weed-killers on roadside vegetation, and the influence of hedges on both agriculture and wild life. All of these raise practical questions of great significance.

The main theme of the Conference was that all over the world conditions are becoming increasingly altered by human activities to the detriment of animals and plants. This must be accepted as an inevitable trend, to be taken into account in all future efforts for the protection of nature. The development of the landscape, the matrix of nature conservation, thus becomes a matter of public concern. Scientific principles constitute the only sound basis for this, Dr. P. Faegri of Norway stressed the importance of abandoning romantic ideas of preserving or restoring a supposedly 'natural' fauna and flora. There were, he considered, only three independent variables operating on landscape—the climate, the soil, and biotic factors, of which by far the most important was man. The aim of nature conservation should be to seek to modify technical and economic influences in a direction most favourable to achieving an equilibrium of existing plant and animal communities between these three factors, climatic, edaphic and biotic; and wherever possible enriching their variety and their opportunities for development.

If the nature conservation movement is to be in a position effectively to influence the treatment of the landscape, it is essential that reliable scientific advice on the basic problems should be available—as is now the case in Great Britain thanks to the creation of the Nature Conservancy in 1949. Such scientific information as exists should be pooled internationally; where no scientific data are available, steps should be taken to secure them by a full programme of research. Examples were the biological aspects of water supply and hydro-electric schemes, and of pollution by oil and other substances. It was reported that the whole problem of water pollution will be discussed at the Third Congress of this International Union which will be held in Venezuela next year. A further 'problem needing urgent research is that of the ecological factors involved in the maintenance, increase and decrease of animal and plant populations, especially in those environments acutely affected by modern civilisation.

Another urgent problem which the Conference discussed was how to provide adequate, up-to-date information on the principles and practice of nature protection in a simple and accessible form. This information needs to be put before the general public, and also teachers; it should also reach those who are professionally engaged in changing the landscape, such as engineers, farmers, foresters and town-and-country planners. Professor Ghigi stated that one of the main difficulties which the nature protection movement meets in Italy is due to the lack of teaching in botany, zoology and geology in public education since 1922, but this is now being remedied.

It was urged that in all countries the nature conservation agencies should be given an early opportunity of examining proposals for changes in the landscape so that they can advise on minimising damage to the natural animal and plant communities. Lord Hurcomb (Great Britain) stressed the need to effect liaison with engineers engaged on any large-scale project affecting the landscape.

The second theme was that of the management of nature reserves. In this connexion the problems of the small reserves in Europe (e.g. Wicken Fen in Cambridgeshire) are quite different from those of the huge game reserves and national parks in Africa, such as the Kruger National Park. It was generally agreed that every country should carefully select areas representing the principal biogeographical complexes of that country, and preserve them. This requires protective regulations enforced law, and the sympathy of the local public. In Great Britain this preliminary selection has been carried out, and the Nature Conservancy has the task of securing the preservation of the areas selected.

The discoveries made by Dr. Robert Broom, Dr. Raymond Dart and Dr. L. S. B. Leakey in Africa have led to the complete rejection of the old theory that Man originated in Asia, and Africa is now considered to have been the cradle of the human race. Scientific opinion has indeed swung so far away from the old idea that it is now considered probable that the great apes of the Far East are also descended from an African stock, which merely anticipated Man in an easterly migratory movement before he had appeared on the scene. This article is written by Mrs. Cole, who has worked in Africa with Dr. Leakey. The pictures are drawn by Maurice Wilson who is engaged in making reconstructions of the various species mentioned in this article for the Natural History Museum; readers will remember his work in the section dealing with Man's ancestry in the Festival's Dome of Discovery.

Man's African Relatives

S. M. COLE, F.G.S.

In spite of the really startling discoveries, made in both Asia and Africa during the present century, which have done a very great deal to increase our knowledge of man's ancestry, it is still impossible to lay our hands on any particular fossil and say: "It was at this point that men and apes branched and went their separate ways." Probably this point will never be determined: there can be no such thing as *the* missing link. Undoubtedly there are many links; they have been found in Java, in China, in South Africa and, going back about 30 million years before man ever appeared, in East Africa.

In order to discuss his origin at all, we have to get back to the definition of man. In this definition no scientist seems to be able to help us. At a meeting of the Linnaean Society this year, some of the best anthropological brains in this country tried to decide the question "What is Man"? but no positive answer was forthcoming. An American writer, Dr. Howells, has asked how we shall know man when we see him. "If we say, because he will be wearing a human foot (i.e. a foot with an instep, signifying an upright posture)", he writes, "then he will have to wait for a fossil foot, something which is almost never found. If we retreat to the teeth, we are in another kind of dilemma, because we have a gradual and almost unbroken series of changes in teeth from ape to *Homo sapiens*, and a dividing line could be settled upon only arbitrarily. The same is true of the skull in general, for there is not a great gap between the man-like South African apes and the ape-like Java men. The time is coming when man and apes can be put in separate families only if we ignore the fossils."

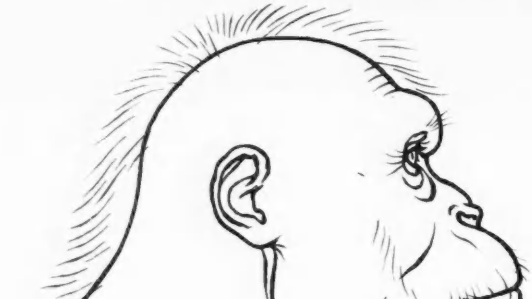
This indeed presents a pretty problem. If we are to ignore the fossils, the only clue to our ancestry we are ever likely to possess, how then shall we make the distinction? We may define man as having the power of speech, but no scientist has yet been able to determine from a fossil brain cast (which in any event is very rarely obtainable) whether the particular lobes involved are sufficiently well developed for the animal to have been articulate. Neanderthal man has a brain whose dimensions equal, if they do not exceed, those of our own, but nobody knows whether he could communicate ideas to his fellows or whether he merely roared with rage, grunted when he sensed danger and possibly made soothing sounds to his unattractive spouse.

We may say that man can fashion tools and create them for some specific purpose, as opposed to an ape seizing the nearest boulder or coconut to hurl at an enemy. Unfortunately man did not always have the consideration to leave his tools to be picked up conveniently near his corpse. In spite of careful and prolonged search, no worked tools have been found associated with the South African australopithecine fossils, although Professor Dart has pointed out that baboon skulls—and indeed most of the australopithecine skulls themselves—show "localised fractures which must have been produced by well-aimed blows on the head with some sort of weapon", such as the "humerus of the larger ungulates". Cracking a skull with a humerus, however, is not quite the same thing as deliberately flaking a lump of rock to make it into the most useful weapon for an intended purpose.

Again, Professor Dart believes that one at least of the South African fossil apes could use and control fire; hence the name of this species—*Australopithecus prometheus*. But the remains of charcoal in the layer of pink breccia at Makapan containing this fossil is perhaps somewhat dubious. Whether we regard these creatures, with Professor Dart, as "intelligent, energetic, erect and delicately proportioned little people", or as repulsive cannibal monsters is a matter of opinion, but as will be seen presently, we cannot leave them out of the family tree, and we have more reason to hail them as brother than has the gorilla or chimpanzee.

It seems likely that we shall have to be satisfied that there *is* no dividing line between the Hominids (man) and Hominoidea in general (which includes man and the anthropoid apes). Inquiries made during the past twenty years or so have established beyond all doubt, however, one or two important facts which, though they may seem obvious to us now, were by no means accepted by any other than a few initiates until recently. The myth that man is descended from the living apes, or creatures similar to them, has now been dispelled. The great apes are far too specialised for them ever to have been in the direct line of man's descent. Rather we should look to primitive creatures such as the East African *Proconsul* to give a hint as to what our ancestors were like. That is not to say that *Proconsul* himself led in the direct line to man, but our forebears must have been as unspecialised as he. *Proconsul* lived during the Lower Miocene period, that is, about 30 million years ago. Thus another belief has been dispelled—that man is something quite new and altogether phenomenal which suddenly appeared a few thousand years ago. The process of evolution of living organisms was very gradual: Prof. Zeuner, for instance, considers that the fastest rate of evolution of animal species under natural conditions was

FIVE BRANCHES OF MAN'S FAMILY TREE



PLESIANTHROPUS

PROCONSUL

NEANDERTHAL MAN

ADULT GORILLA

YOUNG CHIMPANZEE

about 500,000 years per species-step, and there is no reason to think that the rate of evolution of man should have been exceptional and different from the evolutionary rate for other animals.

Homo sapiens probably goes back at least half a million years, to the beginning of the glacial epoch. Several other genera of men are known, such as the *Pithecanthropus* group from Java and China, which go back nearly as far. This statement may cause some surprise, since it is generally supposed that the so-called "primitive" Pithecanthropus group must antedate the much more highly developed *Homo sapiens*. The discovery of a jaw of *Homo sapiens* type in Lower Pleistocene deposits at Kanam, on the shores of the Kavirondo Gulf in Kenya, however, does make it appear at least possible that modern man existed at a very early date, though it needs to be stated that this evidence is still not accepted by some experts.

Before *Pithecanthropus erectus*, there lived in Java during the pre-glacial period a race of creatures which are generally classed as men and not apes. They are known as *Pithecanthropus robustus* and *Meganthropus*. Owing to their very massive jaws, they were formerly ranked (by Dr. Weidenreich) as a race of giants, but in the light of recent material from South Africa—to which the specific name of *Paranthropus crassidens* has been given—it is now apparent that a relatively small creature may have a tremendously massive jaw, and so it is no longer assumed that the forms from Java were giants.

When we recognise how remote are our chances of finding a fossil of an animal that lived nearly a million years ago, we realise that it would be surprising indeed if yet earlier forms of man had not existed without our knowledge. For a fossil to be preserved at all, it has to have been buried (either purposely or by natural agencies, e.g. through inundation by a swamp or a river; or an animal given to frequenting caves could have its bones preserved by a fall of rock from a cave roof). It is improbable that man in his earliest stages took the trouble to bury his dead, and his scattered bones would then be at the mercy of predatory animals—carnivores of all kinds, hyaenas and so on, and little would be left for posterity. In addition to these hazards a body, even after it has been buried, whether by human or by natural agencies, has only a very slender chance of ever being discovered by a fossil-hunter of today. Only when an eroded gully has exposed a fossil to the surface, and we happen to arrive in time with our picks and shovels before wind and rain have disintegrated the bones, is the treasure recovered.

The Earliest Ape Skull

The first primates, dating from the beginning of Tertiary times, are represented by tarsiers and lemurs and certain indeterminate animals which cannot be properly classified as either. Indeed it is even uncertain whether some of the very early forms (the tree shrews) should be classed as primates or as insectivores. The first true apes, *Parapithecus* and *Propliopithecus*, come from Oligocene beds of the Fayum, Egypt. These forms are probably related to *Limnopithecus* from Kenya, which is mentioned later. In East Africa, there seems to have occurred, during the early part of the Miocene period (which followed the Oligocene), a sudden flourishing of apes, a phenomenon which is by no means uncommon in the history of evolution.

Dr. L. S. B. Leakey's team, exploring a small area around the Kavirondo Gulf of Lake Victoria and on certain islands in the lake (Rusinga Island proved particularly fruitful), have lately found an astonishing number and variety of fossils which show how great and diverse must have been the ape population in East Africa 30,000,000 years ago. We have already noticed how rare it is for a fossil to have been preserved at all, and how it is still more rare for it to be uncovered by us today, and yet on the small island of Rusinga alone the bones of over a hundred individual apes have been found, and these represent the remains of at least three different genera and six different species.

The smallest of the fossil apes are called *Limnopithecus legetet* and *L. macinnesi* (which is slightly larger); these forms are probably ancestral to the gibbon. The genus *Sivapithecus*, which was already well known from late Miocene or early Pliocene beds in the Siwalik Hills in India, is represented in this locality in East Africa, though it seems to be uncommon. The most interesting specimens, however, are of the genus *Proconsul*, which includes *P. africanus* (an ape intermediate in size between a gibbon and a chimpanzee), *P. nyanzae* (about the size of a chimpanzee) and *P. major* (the size of a large gorilla).

In all three forms, the dentition is very similar, so that it was difficult to differentiate between the two smaller species especially on the basis of teeth alone. When Mrs. Leakey discovered a whole skull of *P. africanus* in 1948, however, the difference between the species became clear. This discovery was a highly important one and was the culmination of many years of hard work and diligent search among the sun-scorched gullies of Rusinga Island. It is the earliest primate skull known from any part of the world: previously the only data available as to the appearance of the most primitive apes was based on isolated teeth and fragments of jaw. These are the hardest parts of the skeleton and so most commonly preserved. Happily they are also the most diagnostic and easily identifiable parts.

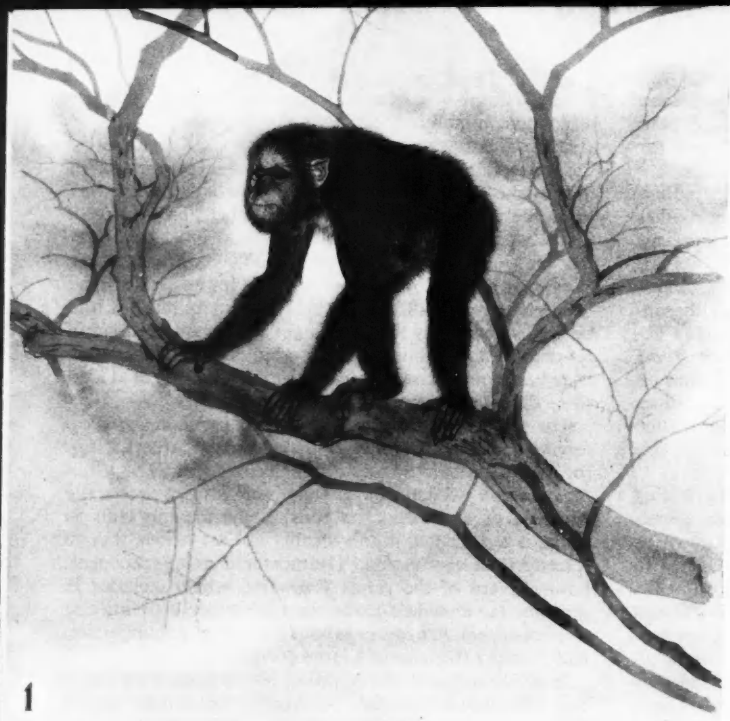
This early Miocene ape skull from Kenya has revealed many interesting features, some of which had already been guessed while others were a little surprising. It has confirmed the fact that *Proconsul* was essentially unspecialised in character. Features such as a simian shelf* and the pronounced brow ridges (or torus), which are so characteristic of modern apes, had not yet made their appearance and are apparently late specialisations.

Professor Le Gros Clark, who has been studying this material in Oxford, has been careful to point out that a number of features of *Proconsul* are more typical of the cercopithecoid or monkey stage than they are of modern anthropoids. Nevertheless, there are others which are more 'human' (or, more correctly speaking, 'un-ape-like') than any shown by the great apes today.

Among these features may be mentioned the following:

1. Absence of brow ridges.
2. A more vertical chin than is found in modern apes.
3. Absence of a simian shelf.

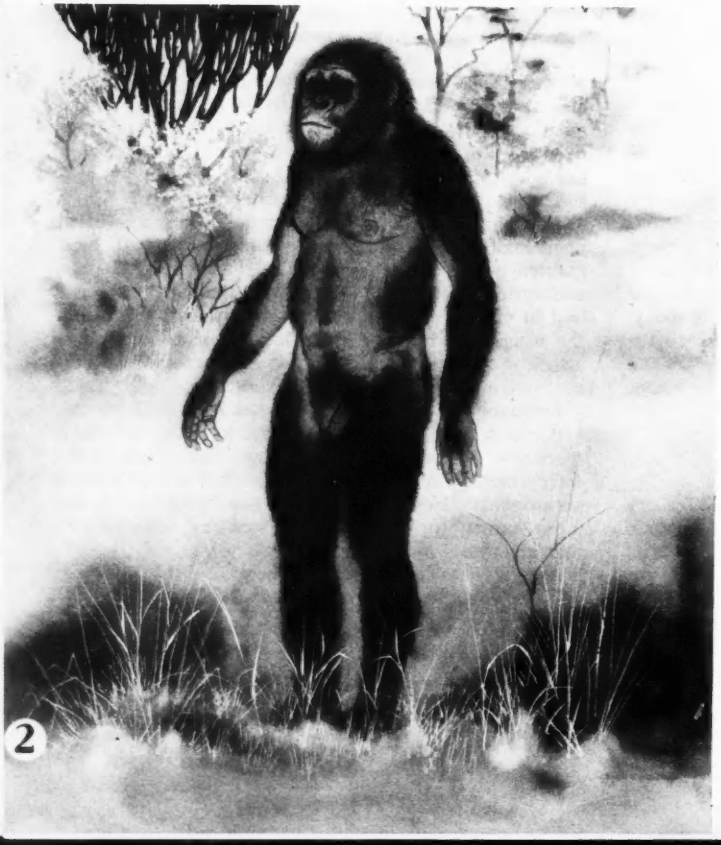
* At the back of the chin region, or symphysis, in the case of apes there is a bony projection known as the simian shelf which serves as an extra reinforcement for the mandible. This shelf is never found in man.



1

1. PROCONSUL. *This reconstruction is based on a complete sku various limbs and bones. The face is given a monkey-like rather than lower part of the nasal aperture, which narrows to form a groove be incisors. The straight, slender shaft of the thighbone indicates tha built and were agile like monkeys. The foot was designed for r* Proconsul *was almost certainly not exclusively tree-living. It live million years ago.*

2. PLESIANTHROPUS. *A complete skull of this genus of man- parts of skulls of both sexes. The height of the cranium above the than in man, is nevertheless greater than in any of the modern apes that of a human being, but the form of the acetabulum (the socket i lates) suggests that the thigh bones turned outwards more than th of the limb bones indicates that the australopithecine apes could wa*



2

3. PITHECANTHROPUS ROBUSTUS. *This ape-like man facial conformation than the better-known P. erectus. The crani heavy brow ridges, though the forehead region has not been found. though its shape is typically human, and the teeth is colossal. Th necessarily mean that* P. robustus *was particularly large in his boc It seems probable that the form was of a coarse Negroid type, similar*

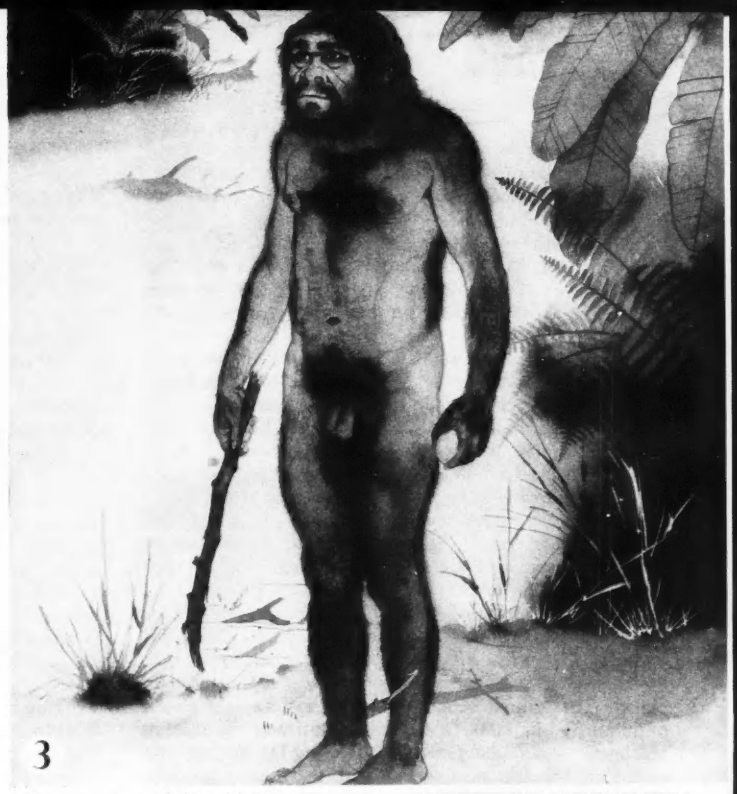
4. THE NEANDERTHAL MAN. *Even today in the Neander its corresponding number in* Homo sapiens: *this is true even de rounded ribs. Anatomically it would be impossible for modern man dant. The brain was no smaller than ours, in fact the fossil fron brain larger than the average modern European. The bones of th is heavy, and the cranium is typically long, wide and flat in shape magnum indicates that the head was held forward and the neck mu The bow-shaped thigh bones make it apparent that Neanderthal while the shape of the vertebrae indicates a curved back.*

struction is based on a complete skull of **Proconsul africanus** and
e is given a man-like rather than an ape-like appearance by the
which narrow form a groove between the roots of the central
haft of the bone indicates that these creatures were lightly
ys. The foot was designed for rapid running movements, and
not exclusively tree-living. It lived in East Africa about thirty

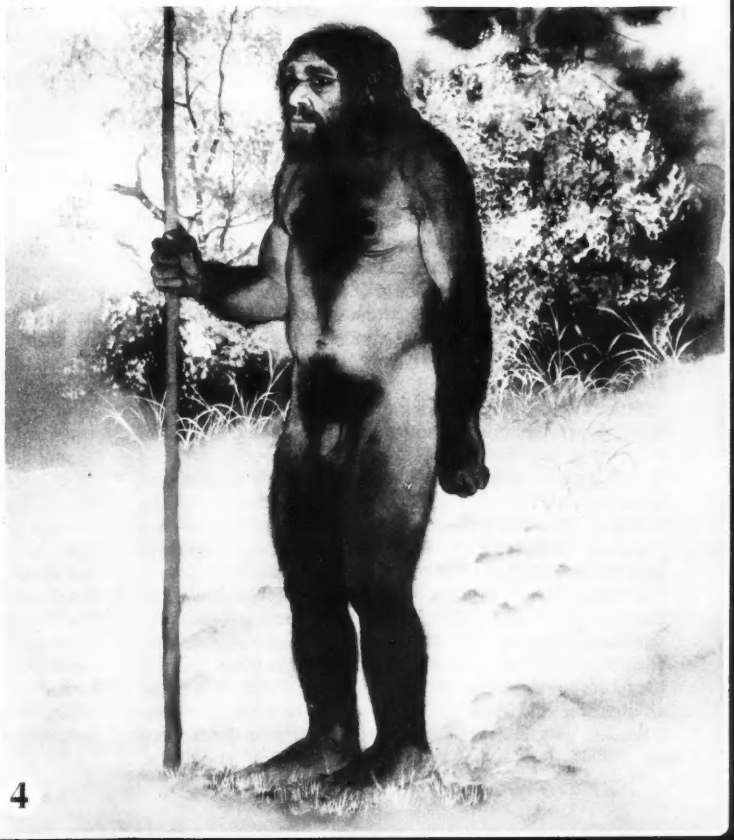
omplete skull of this genus of man-like ape exists, and also many
e height of the cranium above the orbits, while considerably less
ter than in any of the modern apes. The pelvis is very similar to
rm of the acetabulum (the socket in which the thigh bone articu-
nes turned outwards more than they do in man. The formation
he australopithecine apes could walk upright.

OBUSTUS. This ape-like man from Java has a more bestial
er-known P. erectus. The cranium is low, which presupposes
ehead region has not been found. The jaw is extremely massive,
an, and the tooth is colossal. This powerful mandible does not
s was particularly large in his body, which is purely conjectural.
ns of a coarse human type, similar to Pekin man.

AN. Every bone in the Neanderthal skeleton is distinctive from
no sapiens: this is true even down to the ankle bone and the
ld be impossible for modern man to have been his direct descen-
than ours. In fact the fossil from La-Chapelle-aux-Saints had a
dern European. The bones of the skull are very thick, the brow
cally long, wide and flat in shape. The position of the foramen
as held forward and the neck must have been very thick indeed.
e it appears that Neanderthal man walked with bent knees,
ndicates a curved back.



3



4

4. Level wear of the external and internal projections of the molars, showing that *Proconsul* chewed in a manner similar to man and unlike the anthropoid apes.
5. The shape of the dental arch is intermediate between the horse-shoe curve in man and the parallel-sided arch in apes.
6. The small and rounded condyles on the lower jaw, which are larger and flatter in modern apes. (The condyles of the lower jaw are rounded protuberances which fit into sockets on the upper jaw.)

Professor Le Gros Clark has also drawn attention to the fact that the slender limb bones of these Miocene hominoids were sufficiently generalised in character to allow for their subsequent evolution along divergent lines; one line of evolution led to the heavy and slightly bent limbs acquired by the anthropoid apes (Pongidae), and along another line evolved the type of limb which is associated with the erect posture developed by man. It is assumed, from the appearance of the limb bones, that these Miocene hominoids were not tree-living or brachiating in their habits.

Fossil fruits and seeds found in the same horizons of the deposits in which the ape material occurred indicate the presence of plants, some of which are characteristic of forest vegetation while others are typical of the flora of plains. The animal remains also suggest the same sort of mixture of habitats, though the majority of the animals belonged to a fauna typical of plains. Dr. Leakey has explained this by postulating that there were wooded valleys fringing the rivers which drained into the lake, and that there was open grassland between; such conditions are common in East Africa today. The probability is that the Miocene primates lived both among the trees and on the plains, and did not need limbs adapted for an exclusively arboreal mode of life. That a lake existed at that time (it could not have been the present Lake Victoria, which was not formed until later) is certain; this is proved by the extensive lake beds exposed on the island and also by the presence of the very numerous crocodile fossils.

It is apparent from the skull of *Proconsul africanus* that the brain could not have been much more highly developed than it is in the cercopithecoid (i.e. the 'monkey') stage. The highly developed brain of man, with the expanded brain-case and foreshortened muzzle, is of course a very late specialisation. The *Pithecanthropus* group of Middle Pleistocene times still had very flat-topped skulls, with practically no forehead, a kind of skull which here represents a late manifestation of the generalised ancestral form.

Among the rather primitive characteristics exhibited in the upper dentition of *Proconsul*, one of the most striking is the strong development of an internal ridge (known as a *cingulum*) in the molars. Professor Le Gros Clark believes that the elaboration of this cingulum is a specialisation of this genus, and may preclude the possibility that it is ancestral to the somewhat later *Dryopithecus*, a form fairly widespread throughout Europe and Asia and showing no such cingulum. On the other hand, vestiges of an internal cingulum are sometimes found in the upper molars of the chimpanzee and Professor Le Gros Clark says, "the pronounced cingulum of *Proconsul* may have undergone retrogressive changes so as to lead to a type of molar characteristic of the modern chimpanzee". The comparatively small size of both the upper and lower incisors in *Proconsul* is remarkable in comparison with modern apes, though, in *P. major* especially, there is a powerful development of the canines.

South African Man-like Apes

Separated by a gap of some 30 million years from the Miocene apes of East Africa came the remarkable Australopithecinae, present in the southern part of Africa. It is probable that these creatures date from very early Pleistocene times (i.e. nearly a million years ago), though the geological evidence of their exact age is unfortunately inconclusive.

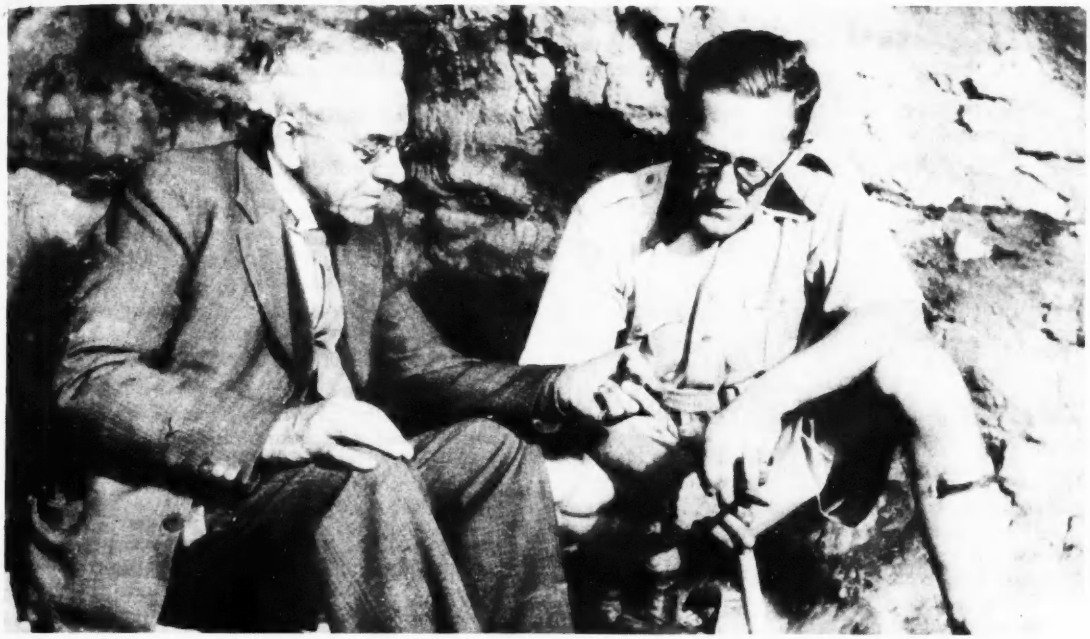
In 1924 Professor Raymond Dart discovered an immature fossil ape skull at Taungs, and this created a great deal of excitement and controversy. It was not until 1936, however, that the late Dr. Robert Broom set out to find an adult specimen, which he succeeded in doing within a few months of the start of his search. The story of his discoveries of *Plesianthropus transvaalensis* and *Paranthropus robustus* is now a classic.

Possibly his methods might be considered a little drastic. In a letter written in 1947 Dr. Broom says: "I have started working at Sterkfontein . . . I blasted a site near where the Sterkfontein skull was discovered and in our blast got portions of two new skulls. . . . It was only yesterday that we got out these bits, so it will take some time to look all over for more, for with the blast some fragments had been thrown a distance. I am doing this blasting in defiance of the law." The extreme hardness of the breccia in which the fossils are embedded makes it wellnigh impossible to extract them except by use of explosives and, although some may regret that this treatment needs to be employed, it seems preferable to obtain broken fossils, which can be pieced together afterwards, than no fossils at all.

So far more than thirty australopithecine skulls, together with more than 150 teeth and several pelvic bones, have been recovered from the three main sites—at Sterkfontein, Makapansgat and Swartkrans—where he worked. Dr. Broom's death early this year was an irreparable loss, but he has pointed the way and shown how others can carry on from where he left off.

Recently Dr. Broom's assistant, Mr. J. T. Robinson, visited London and brought some of the latest finds with him. These included seven massive mandibles and skull fragments of *Paranthropus crassidens*, which shows a close resemblance to the powerfully jawed *Meganthropus* of Java. He also brought an extremely interesting fossil which has been named *Telanthropus*. This is far more human in appearance than any of the other Australopithecinae, and Mr. Robinson maintains that certain details of the cusp pattern of the molars are only found in man. Other anthropologists believe that this specimen is within the *Paranthropus* range, and that it does not warrant the creation of a new genus. But this point cannot be decided until more material is forthcoming.

If the status of these fossils were to be judged by the teeth alone, it would be difficult to draw the line between the man-like apes of South Africa and the ape-like men of Java.



This year has seen the death of Dr. Robert Broom (*left*). This photograph was taken at the "Cave of Hearths" in the Makapan Valley near Potgietersrust, where many valuable finds have been made. Dr. Broom arrived in S. Africa in 1896, and began to collect and study fossils in the time he could snatch from his medical practice, which he gave up in 1903 to become Professor of Geology and Zoology at Victoria College, Stellenbosch. Most of his early work was concerned with fossil reptiles of the Karroo. Circumstances forced him to return to medical practice, and even to become an insurance agent for a short time. Eventually General Smuts arranged for him to become Keeper of Vertebrate Paleontology and Anthropology at the Transvaal Museum, Pretoria, where he was able to devote his time to tracing the ancestry of man. Among Broom's discoveries were the bones of *Plesianthropus* and *Paranthropus*.

Hominid or man-like characteristics found consistently throughout the Australopithecinae include the following:

1. Small canines and incisors.
2. Flat wearing of the canines.
3. Absence of a gap (diastema) between canines and incisors.
4. Biscuspid (i.e. with two projections) rather than sectorial type of pre-molar.
5. Flat wear of the molars.
6. Curved contours of the dental arch.
7. An almost vertical chin.
8. Greater height of the cranium above the orbits than is seen in modern apes, though this is small compared with the same measurement made on a human skull, and low position of the inion (the external bony protuberance on the occiput, at the back of the skull).
9. The pelvis is very similar to man's, and unlike that of the modern anthropoids.

The position of the *foramen magnum* (which is the hole at the base of the skull through which the spinal column passes) in the australopithecine apes is relatively forward, and intermediate between the position characteristic of man and the position characteristic of apes. This feature, considered in conjunction with the slope of the thigh bone (femur), indicates that these creatures walked in an upright position. They were not adapted for life in the trees, and this is also true of all the other fossil mammals found associated with them. (Several of the latter were, in fact, desert types.)

Despite the many features listed above which are more human than ape-like (and the list is by no means complete), a glance at their skulls will be sufficient to dispel any idea that the creatures could be classed as humans. The nasal part of the face is characteristically concave (in man it is almost vertical), and so the face must have had a squashed-in appearance. The brain capacity barely exceeds that of a gorilla, though in comparison with their size the brains of the Australopithecinae were relatively large. The brain capacity of a gorilla goes up to about 580 cubic centimetres; that of modern man averages 1350 and may be as low as 900. The second *Pithecanthropus erectus* skull is estimated to have a brain capacity of 770 cubic centimetres. The larger Australopithecinae probably had brains intermediate between that of the gorilla and that of *Pithecanthropus*.

One could, of course, quote many examples from the anatomy of these creatures to show that they are by no means human, but the fact that they probably lived contemporaneously with true man (even with *Homo sapiens*, if the disputed Kanam jaw is really Lower Pleistocene in age) is in itself of the greatest interest. The perplexing mixture of man-like and ape-like features which they exhibit makes them unique as far as our knowledge goes at the present time.

Their geological age, although it has not yet been accurately determined, is certainly not earlier than the

[Continued on p. 342

Science Education in Russia

WILLIAM E. DICK, B.Sc., F.L.S.

THE scientific power of a country ultimately rests on the existence of an effective and healthy system of science education. This is recognised by the Soviet leaders. It was implicit in the famous analysis Stalin once made of Russian backwardness in five major fields of endeavour—he then placed the cultural backwardness immediately after military weakness, and before shortcomings in the fields of politics, industry and agriculture. He did on that occasion say, "We must make good this lag in ten years."

Since then the improvement of education, and in particular of science education, has been made a top priority. This sense of urgency has been well conveyed by Walter Bedell Smith, American ambassador to Moscow in his book *Moscow Mission 1946–1949*.

> *Hurry, hurry, hurry!—this was Stalin's exhortation to the Soviet people, whether they were building a steel mill, composing a symphony, harvesting a wheat crop, writing a book, constructing a hydro-electric dam, performing in a drama or drilling an oil well. The military, cultural, political, industrial and agricultural revolutions, which were to make the Soviet Union impregnable to attack, were to be carried through in feverish haste.*

Science education had in fact been recognised as crucial to the problem of reconstructing Russia after the Revolution, the part that science must play in the process being clearly expressed by Lenin when he said, "We must take both technique and science and send them into action."

The expansion of teaching facilities, in particular science teaching facilities, has indeed gone on with feverish haste. There was, by 1945, for instance, a vast army of scientists working on Russian agricultural problems; the staff of the 100 agricultural research institutes and 865 experiment stations scattered throughout the Soviet Union totalled 14,038 scientific workers—7892 of whom were graduates. Such a service could only be supplied with trained scientists by a vast extension of science education in the years that followed 1917.

Expansion of the facilities for training the men and women needed for the schemes for expanding industrial and medical research had to be on the same grandiose scale. Certainly the extent to which these services were expanded is an indication that the training facilities had been organised. Thus by 1935, there had come into existence one hundred institutes for industrial research, and their staffs totalled over 33,000; of these 33·5% were scientists, and 28·1% technicians, engineers and laboratory assistants.

The impression is often conveyed—*sedulously* conveyed, one might add—that this expansion of science teaching was something miraculous, as though there had been nothing worth calling science teaching in Tsarist days. This impression does not correspond to the truth. What is true is that in the days of Lomonosov (*see* C. L. Boltz's article, DISCOVERY, August 1951, p. 251 onwards) there was practically no teaching of science in Russia. But then Lomonosov dates back to 1711, and by 1755 Moscow University had been founded on a plan drawn up by Lomonosov. The Academy of Sciences, which had started in 1725, provided a centre at which students could study under the early Russian Scientists. To quote S. I. Vavilov on this period of Russian history:

> *Gradually there began to arise, by the side of the Academy, other centres of learning—universities and specialist higher schools at Moscow, Kazan, Kharkov and other cities, the Academy of Military Surgery at St. Petersburg, learned societies and institutions, and military educational establishments.*

Bare facts, figures and dates, taken by themselves, can be very misleading. It does not, for example, convey any clear picture of the state of educational affairs obtaining in Russia in Tsarist days to say that Euclid did not begin to be taught in Russia until the end of the seventeenth century. To say that is to convey the same kind of bias which would result if one said that science teaching in British public schools did not begin until 1837 and that the first school science laboratory was not built until 1854.

Science Teaching in a Military Academy

One does need to get some accurate idea of what the quality of science teaching was during a particular period. Vavilov referred to the science teaching in military educational establishments. One such establishment was the College of Pages, which took sons of men who had been officers in what was roughly equivalent to the British Brigade of Guards (this was the Izmaylovsk Regiment) and gave them a military education. There exists a good record of what this school was like in the pages of Prince Kropotkin's *Memoirs of a Revolutionist* (London, 1906), for he studied in this school about the middle of last century. (This was a time when the Tsar, Nicholas I, insisted on all the sons of the nobility embracing a military career). Kropotkin's record is extremely valuable, because he was a most careful observer, later to make his mark as a scientific geographer who established the structure of the main mountains in the east of Russia.

Prince Kropotkin and his two brothers went to this school, after receiving a basic education from a French tutor. Prince Kropotkin was fifteen when he entered the College of Pages at St. Petersburg. This was the year 1857, a time when Russia had just awoken from "the heavy slumber and the terrible nightmare of Nicholas I's reign." Education was spreading; in that same year, for instance, the first high school for girls was opened in St. Petersburg, an advance which was supported by the Empress Alexandrovna and the Grand Duchess Hélène Pavlovna.

The head of the College was a Frenchman in the Russian service. The educational director, a well qualified colonel

This article is the fourth in our series on Russian Science. No. 1 (in the July 1951 issue) was by Prof. Eric Ashby and dealt with Russian Botany; No. 2 (August) was on Russian Physics, and No. 3 (September) was on Russian Chemistry. The final article summing up the series will appear in December.

of artillery named Winkler, whom Kropotkin describes as being a good mathematician and a man of progressive spirit. The elements of algebra were taught by a first-rate mathematician, named Sukhonin; he was a tutor to the Tsar's son, who actually took the algebra course at the College. Russian literature and German were taught by two university professors: both of them were men of outstanding quality, judged by any standard of comparison. They exercised immense influence on their pupils, and so impressed Kropotkin that he wrote:

In Western Europe and probably in America this type of teacher seems not to be widely spread; but in Russia there is not a man or woman of mark who does not owe the first impulse toward a higher development to his or her teacher of literature. Every school in the world ought to have such a teacher. Each teacher in a school has his own subject, and there is no link between the different subjects. Only the teacher of literature, guided by the general outlines of the programme, but left free to treat it as he likes, can bind together the separate historical and humanitarian sciences, unify them by a broad philosophical and humane conception, and awaken higher ideas and inspirations in the brains and hearts of young people.

Kropotkin's chief studies were mathematics, physics and astronomy. He did not lack for sound teaching in biology either, for in 1858—that is, *before* Darwin published his *Origin of Species*—we find Kropotkin attending a short course of lectures by Roulier, professor of zoology at Moscow University, on evolution—to quote Kropotkin's exact words, "on transformism". He and his brother Alexander had long discussions about evolution, and in the course of their many conversations about this subject they raised fundamental points about the origin of variations, and the chances of these variations being transmitted and accentuated which were later made and elaborated by Weissmann, Spencer, Galton and the neo-Lamarckians.

In the second form at the College the young cadets began to study physics. Here again Kropotkin makes it clear that he derived much benefit from a first-class teacher:

He was a good mathematician, and taught us physics on a mathematical basis, admirably explaining at the same time the leading ideas of physical research. Some of his questions were so original and his explanations so good that they have engraved themselves for ever on my memory.

The military schools appear to have been well served by textbooks; says Kropotkin, "Most textbooks for the military schools had been written by the best men at the time." The physics textbook, he wrote afterwards, was somewhat out of date, and so Kropotkin's teacher taught the subject according to his own system. The following passage in Kropotkin's *Memoirs* is very interesting:

He began to prepare a short summary of his lessons . . . for the use of our form. However, after a few weeks it so happened that the task of writing this summary fell upon me, and our teacher, acting as a true pedagogist, trusted it entirely to me, only reading the proofs. When we came to the chapters on heat, electricity, and magnetism, they had to be written entirely anew, and this I did, thus preparing a nearly complete textbook of physics, which was printed for the use of the school.

Chemistry was already a thriving subject in those days. In his *Memoirs* Kropotkin refers to the theories of Gerhardt and Avagadro, and the inspiration which the Periodic Law brought—here it is significant that Kropotkin gives credit in connexion with the Periodic Table to the three men, Mendeleeff, Lothar Meyer and Newlands, which shows that chemistry as taught in Russia was, in those days at least, a thoroughly international subject. This period was one of great scientific activity, and there can be no doubt at all that current scientific literature reached Russia in sufficient quantity to enable the scientists and students to keep abreast of the progress being made all over the world and on every sector of the scientific fronts. There was evidently no lack of periodicals or of books; according to Kropotkin, "Numbers of excellent books were published at that time in Russian translations."

There is a familiar and modern touch about the chemical laboratory which Kropotkin and his friends rigged up for themselves in a bedroom:

Five or six of us joined together to get some sort of laboratory for ourselves. With the elementary apparatus recommended for beginners in Stockhardt's excellent textbook we started our laboratory in a small bedroom of two of our comrades, the brothers Zasétsky. Their father, an old retired admiral, was delighted to see his son engaged in so useful a pursuit, and did not object to our coming together on Sundays and during the holidays in that room by the side of his own study. With Stockhardt's book as a guide, we systematically made all experiments. I must say that once we nearly set the house on fire, and that more than once we poisoned all the rooms with chlorine and similar stuffs. But the old admiral, when we related the adventure at dinner time, took it very nicely and told us how he and his comrades nearly set a house on fire in the far less useful pursuit of punch making . . .

Following the example set by such students of military affairs as Napoleon and Suvarov, Kropotkin and his friends chose either the artillery or engineering branches of the Army as offering the most congenial prospects of promotion. "In order to do so we had to prepare in higher geometry, the differential and the beginnings of the integral calculus, and we took private lessons for that purpose. At the same time, elementary astronomy being taught to us under the name of mathematical geography, I plunged into astronomical reading, especially during the last year of my stay at school. The never-ceasing life of the universe, which I conceived as *life* and evolution, became the philosophy of my life," he wrote.

One cannot help but be impressed by the extent to which science entered into Kropotkin's formal education; certainly science was essential to the cadet who wanted to become an artillery officer or military engineer, but the fact that Kropotkin could end his studies at the College of Pages with so firm a scientific philosophy as that expressed in the last quotation I have given is a clear indication of the quality of the science teaching at the College. Only first-class science teachers who were given sufficient time in the curriculum to develop their subjects properly could have

influenced their students in the way that Kropotkin was influenced, for there were many other subjects besides science to be learnt,* and these other subjects might well have neutralised the full force of the science teaching.

Kropotkin and his fellow students were given a chance to concentrate on those subjects which particularly interested them: he says, ". . . some latitude was given to us in the choice of subjects we liked best, and, while we underwent severe examinations in these chosen subjects, we were treated rather leniently in the remainder". There was much emphasis on the practical aspects of the subjects studied: thus when Kropotkin had learned elementary geometry on paper, he had to re-learn it in the field with poles and the surveyor's chain, and next with the astrolabe, the compass and the surveyor's table: "After such a concrete training, elementary astronomy offered no difficulties, while the surveys themselves were an endless source of enjoyment." Technological progress was not lost sight of, either, and students were encouraged to visit potteries, ironworks, glass and textile factories, for example. It is hard to see what improvements could have been made either in the curriculum of the College, or in the teaching methods used. The *practical* nature of the training he received was the thing that most impressed Kropotkin: he writes of the "powerful aid [educators can] find in concrete applications for helping their pupils to grasp the real sense of the things they learn," and he criticised vigorously those schools where the "longing of the children and youths for *real* work" was being wasted because the teachers took their ideas about how to run a school from the mediaeval scholasticism, "the mediaeval monastery".

Obviously the education which Prince Kropotkin received was the best in the way of science education to be found anywhere in Russia around the middle of last century. But this best was clearly very good indeed; interested readers may care to compare it with the state of science education available to British youths at that time—Rugby, for example (and remember that Rugby was the pacemaker for our public schools), had only just begun (in 1837 to be exact) to teach science. But the context to Kropotkin's schooldays was infinitely less propitious and forward-looking than the context to Tom Brown's schooldays. Russia was about to swing from the extreme of optimism to the opposite extreme—an extreme so devoid of hope that only the people imbued with the strongest sense of fatalism could endure. In 1861 the serfs were promised a substantial measure of freedom—liberty but "not liberty yet, the peasants having to remain serfs for two years more, till February 19, 1863." But by the time that date arrived Alexander II had reversed his policy; the bureaucrats and the Secret Police (the latter began its uninterrupted and horrible career as in Peter the Great's reign) smashed the close relationship which was growing up between the Tsar and his people, and the Tsar gave his blessing to the order to reverse the engines of State—"Reaction, full speed backwards" was the new motto—or the old motto, revived—said Kropotkin.

The ending of the liberal phase of Alexander II's reign brought educational progress to a halt. One of the first reactions to this was an outburst of disorders in the universities—at St. Petersburg, Moscow and Kazan. The University of St. Petersburg, for example, was immediately closed, and the best of the professors left the university (Kropotkin's brother, Alexander, was one of those who left Moscow University at this time). In 1863 revolution broke out in Poland, then a subject province within the Russian Empire. The liberals in Russia were solidly against the Government's attitude towards rebels; everywhere in Russia money was collected to support the *rebels*, and the Russian university students "equipped those of their comrades who were going to join the revolutionists."

Alexander II's policy from now onwards was to prove scarcely less repressive than that of Nicholas I, most despotic of all the Tsars. Liberty and progress were both ended now.

The Need for Technical Education

In Britain at this time, education was looked upon by nearly everyone as the one thing which could enable a man to advance himself, to lift himself by his boot straps so to speak. But in Russia there was no such belief in the idea that education offered a solution to the really big contemporary problems. We find Kropotkin saying (after a passage in which he describes the delights of his life in Siberia as an army officer, an explorer and a geographer), "What right had I to these higher joys, when all round me there was nothing but misery and struggle for a mouldy bit of bread." Or to quote Tolstoy, "A pair of boots is more important than all your Madonnas and all your refined talk about Shakespeare." If Kropotkin and Tolstoy could be reduced to such depths of despair, what of the serfs? The serf living during that period of Russian history had no real hope of even being able to improve himself, and in the circumstances one might have expected a completely negative attitude towards education to exist throughout Russia. But the truth is that the intellectuals of this period (who were usually of noble blood) were so inspired by the ideal of serving the people that many trained themselves in practical affairs and practical skills, and became doctors, doctor's assistants, teachers—even farm labourers and blacksmiths—in order to help the peasants, and went to live in the villages with the peasants.

The value of technical education began to be appreciated, and applied research began to get up steam for just that same reason. Kropotkin wrote this passage about technical education:

> *All Russia wanted technical education, but the Ministry [of Education] opened only classical gymnasia, because formidable courses of Latin and Greek were considered the best means of preventing the pupils from reading and thinking. In these gymnasia only two or three per cent of the pupils succeeded in completing an eight years' course, all boys promising to become something and to show some independence of thought being carefully sifted out before they could reach the last form, and all sorts of measures were taken to reduce the numbers of pupils. Education was considered as a sort of luxury, for the few only. At the same time the Ministry of Education was engaged in a continuous, passionate struggle against all private persons*

* Kropotkin lists the other subjects he had to study at the College: these were history, the Russian code of law, political economy (including a course in comparative statistics), as well as military tactics, military history, artillery and field fortification.

and institutions—district and county councils, municipalities, and the like—which endeavoured to open teachers' seminaries or technical schools, or even simple primary schools. Technical education—in a country which was so much in want of engineers, educated agriculturists, and geologists—was treated as equivalent to revolutionism. It was prohibited, persecuted; so that up to the present time, every autumn, something like two or three thousand young men are refused admission to the higher technical schools from mere lack of vacancies . . . Such was the official St. Petersburg. Such was the influence it exerted on Russia . . .

A factor which must be taken into consideration here is the big difference between the state of industry in Russia and that of industry elsewhere. Russia lacked the newer industries based on technology, and this fact acutely affected the progress of her technical education. Such industries as the petroleum industry, for instance, tended to be developed by foreign experts (the Nobels, for example), with the result that Russians had less chance of becoming well-trained technicians and technologists in these industries than if the same industries had been built up by Russian enterprise. The same thing had previously happened in the case of the railways; the construction of the network of Russian railways involved the employment of many foreigners, and that extreme reliance on outside experts meant that Russia did not gain out of this development any body of engineering skill comparable to that which other countries such as Britain gained from their great period of railway building. (The current claim that the steam engine was invented by a Russian named Polzunov is probably to be explained as a fiction, perhaps with a grain of truth in it, arising from the deep inferiority complex with regard to railway engineering which dates from that period.)

There was thus, one clearly sees, a powerful concatenation of factors which held back scientific and technical education in Russia for a long time. Here is what S. I. Vavilov, the ex-president of the U.S.S.R. Academy of Sciences, wrote on this point in 1946:

Repeating the well-known lines of Lomonosov, one may say that the history of science in old Russia proved beyond doubt

That Platos not a few,
Quick-witted Newtons too,
The Russian land can breed.

But fully to value these "Newtons", to apply their thoughts and scientific discoveries to real life, to build up schools and successors around them—this for the most part was beyond the capacity of Tsarist times. There were good places of higher education, but they were very few, and great scientists in most cases remained solitaries, without pupils to continue their work. There was no one to see to it that all spheres of science and technique were represented in the country. In most important branches of science sometimes not a single specialist existed in old Russia.

Peter I, did a great work: into ancient Russian learning with its Byzantine traditions and inertia, he breathed the new spirit of Galileo and Newton. For two centuries that learning went on growing. It gave Russia Lomonosov, Lobachevsky and Mendeleeff, but it was inadequate in its scope and its penetration into life.

The further development of Russian science was fettered by the reactionary system on which the rule of the nobility and the bourgeoisie reposed.

Soviet Education

The mood which that quotation expresses prevailed at the time the Communists took over Russia, and the energy which was always available in Imperial Russia, but was kept pent up by the lack of encouragement and the lack of facilities, was released in a tempestuous flood once the Soviet Government was able to organise a better system of scientific and technical training. In S. I. Vavilov's words:

From the very first months of Soviet power there began to come into being new universities and places of higher education, both in our capital cities and in the distant provinces. Soviet science began to grow, expand, branch out and become complex, just as the young shoots of plants grow under the influence of life-giving rain after a prolonged drought. . . .

By means of the school, of oral propaganda, of lectures, books, newspapers and the wireless, science penetrated into the very depths of the people. Very rapidly the army of workers in science grew to almost tenfold what it was before the revolution. Whereas previously science was divorced from practical tasks, and scientists not infrequently were distracted by extremely abstract questions, scientific theory now became organically bound up with the requirements of technique and practice. Science became more accessible, more widespread and approached much more closely to the needs of life than had been the case before.

In pre-revolutionary Russia, when people spoke of science, they always in reality had in view individual scientists like Lomonosov, Lobachevsky or Mendeleeff. In Soviet days it has become customary and natural to speak of schools and institutes, of the school of Pavlov, the school of Kurnakov, the TSAGI, the GOI, and so forth, i.e. of considerable collective bodies of scientists.

Prof. Eric Ashby's book, *Scientist in Russia*, is very informative about science education in modern Russia. The schoolchildren learn science from an early age: the amount of time devoted in the school curriculum to science is large, and precise details on this point are available in Ashby's book (*see* in particular pp. 47–55). As Ashby so rightly says, the syllabus laid down by Commissariat of Education for the ordinary Soviet schools is a formidable one, and he explains that there is only one way to get through it—"the didactic way, with *ex cathedra* statement; learning by heart; and in science the minimum of experiment and discussion." This is Ashby's further comment in this connexion:

This is the way which is in fact adopted in spite of the admirable exhortations in each syllabus. It is significant that one ten-year boys' school in Moscow, which I visited in 1945, was built in 1938 and yet has no chemistry, physics or biology laboratory; only horizontal desks, a demonstration bench and preparation room for the teacher. Nor were there replicates of chemical or physical apparatus. In this school experiments were set up as demonstrations, each boy in the class having his turn at setting up experiments. I was told that each boy has a hand in thirteen or fourteen experiments a year.

With so much ground to cover it is inevitable that teaching should be perfunctory: but it does not go uncriticised. One newspaper in 1944 complained of the gap between theoretical knowledge and practical experience, and said "natural science is frequently taught from books alone."

It must be recognised that the traditions of school science teaching in Russia are comparatively young traditions and have still a long way to go before they reach full maturity. (The good traditions of the mid-nineteenth century, which Kropotkin described, affected only a tiny fraction of the people.) Ashby makes it quite clear that it still has not yet reached the sort of standard which Kropotkin would have considered satisfactory! It falls short of the ideal in just those special and important respects which Kropotkin referred to: for instance, it uses *ex cathedra* statements, which are completely out of place in science teaching, for science is the one branch of activity into which the word 'authority' should never enter—the 'authoritative view' is always having to be changed, and the term is more appropriate to discussion of matters religious or political than to matters scientific. Lack of experimental work (by master and pupil) is also a serious obstacle to science teaching, and in so far as scientific training without practical experiments or practical demonstrations fails to satisfy the "longing of the children and youths for *real* work" so the Soviet school described by Ashby falls far short of Kropotkin's standards in this connexion. There seems but little doubt that the Russian teaching of a subject like literature is far more satisfactory than that of elementary science. But it has to be recognised that the teaching of literature in Russia is based upon very ancient, and very fine traditions, and indeed it is a most encouraging fact that the teaching of literature enjoys all its old prestige in modern Russia. Most educated people will agree with the view that literature is a great binding force which brings together what Kropotkin called the "historical and humanitarian sciences" and unifies them into "a broad philosophical and humane conception." Moreover there seems to be comparatively little political bias in the teaching of literature.

The communist bias probably does not affect the teaching of chemistry and physics like it does the teaching of biology. According to the curriculum prescribed in 1942 by the Commissariat of Education (quoted by Ashby, p. 53),

The climax of the course [middle school biology course] is the integration of organic nature through Darwinism which is used as "a basis for the proper understanding of the dialectic materialistic interpretation of organic nature". The course includes in the last year a discussion of "the anti-scientific, misanthropic race perversions of the fascist scientists".

In view of the influence which Lysenko can exert in Russian biology, this raises the disquieting possibility that the pre-graduate teaching of biology may be tampered with in the name of Michurin and the name of Lysenko. Indeed one finds that Ivan Novikov (headmaster of a Moscow secondary school in high standing with the Communist Party and a member of the Moscow Soviet) has already dropped the hint that the syllabus for biology needs immediate alteration to bring it into line with Lysenko's ideas; in *Notes of a School Principal* (Foreign Languages Publishing House, Moscow 1950), he says this:

It is clear to everyone that in connection with the recent decisions of the Lenin Academy of Agricultural Sciences (of which Lysenko is director), the principles and methods of teaching natural science must be seriously reconsidered. But the Ministry of Education has so far failed to supply the schools not only with new syllabuses, but even with any at all detailed, practical instructions on the subject.•

Probably this book by Ivan Novikov provides a better insight into the character of modern Russian schools than any other book available in Britain. Read in conjunction with M. I. Kalinin's *On Communist Education* (1950), it provides the same sort of information about communist schools that Kropotkin provides about the education given at the College of Pages. Novikov has plenty to say about science teaching. Much of the time he is complaining about the fact that syllabuses and textbooks do not pay enough attention to what he describes as "the indisputable priority of our country in many scientific achievements." A textbook of physics (by Sokolov, and used in the tenth-year physics course) is criticised because it gives credit to Thales, Doffe and Gilbert in connexion with electrostatics, but "not a word is said about the fact that the theory of the electrostatic field was originated by the Russian scientists M. V. Lomonosov and Academician Rikhman on the basis of experiments with atmospheric electricity." Similarly he refers to the ignoring of the work of Ladygin and the telescope designed by Maksutov. He says another "outstanding Russian inventor"—Yablochkov—"is mentioned only in passing." The book is criticised, too, for containing a portrait of Hertz but none of Popov. This is his final comment:

This textbook should be thoroughly revised, but there are no signs that it is being done.

Russia is not, however, the only country in the world where the Ministry of Education misses some of the very many new ideas advocated by the influential men. There is always the possibility that, with the policy of the Communist Party in Russia always undergoing rapid change in order to meet changing material circumstances, the old French proverb about "the more things change, the more they remain the same"• covers the contemporary situation, which must encourage the administrators to decide that the policy can best be implemented by making none of the alterations demanded by men like Novikov—in fact, by making as few changes as possible, a method of administration which is not altogether unknown outside Russia!

There is evidently a lack of good juvenile scientific literature in Russia, but then there is a universal lack of such material. Even in Britain there are comparatively few good scientific books worth giving to children. One of the best books available in Russia is Academician Fersman's *Fascinating Mineralogy*. There is, I think, a universal truth in Novikov's remark about the need for such books and his statement that "*These books should be written by people who have a thorough knowledge of their subject, in simple but not baby language.*" (The reaching of this particular objective will necessitate, of course, a considerable change of

• Three years ago the Minister of Higher Education Kaftanov, stated that their aim "is to fill the ranks of the teaching profession with Michurinist biologists." (See Julian Huxley's *Soviet Genetics*, 1949, p. 50).

heart, and possibly it will be necessary to recognise that the distinction between *science* and *popular science* is a false one, better replaced by the assumption that there is only one kind of science, but that there are many kinds of science writing, which can however all be classified into two categories—*intelligible* and *unintelligible*!)

Whether any science can be learnt from science fiction is a universally debatable point, and here Novikov's remark about the influence of science fiction in his school's library is worth noting:

It will be in place here, I think, to say a few words about scientific romances for children. This kind of literature is extremely popular in school libraries and in principle it is really very necessary. A good scientific romance teaches children to dream and to dare, it puts before them, in an easily understood and vivid form, problems which mankind has yet to solve and which are or soon may be on the order of the day. The "romance" part of it should have roots in reality. Besides being well written, interesting and having the right kind of outlook, a scientific romance should make the young reader feel, "True, that doesn't exist yet, but man will surely achieve it." Unfortunately, we still have too little literature of this type. Many books which claim to be scientific romances are simply romances, with nothing scientific about them. One such book, Belyayev's "Amphibious Man", evoked the following apt comment from sixth-grader Remizov: "In depicting his amphibious man, the author ignored the real laws of nature, and what he has imagined has no chance of ever being realised."

University education in Russia has traditions far older than those of primary and secondary education, and here the expansion which the Communist Government set as their target has been far easier of achievement. The scale of expansion is impressive; in 1939, university enrolments totalled 620,000, as against 112,000 in 1913. Eric Ashby's *Scientist in Russia* contains much information about this branch of Soviet education, but a close study of the facts he has assembled in that book shows that, since Tsarist days while there has been a big change in the *size* of the university population, there has not been a truly significant change in the *character and quality* of university teaching, except where the "party line" affects the approach to a particular subject, such as biology. Even the composition of the university population has not changed in the way that a Lysenkoist Communist would expect it to change. The table from Ashby's book, which is reproduced below,

Year	*Workers and their Children*	*Peasants and their Children*	*Employees and Intelligentsia*	*Others*
1925	17·8	23·1	39·8	19·3
1931	45·9	19·4	30·3	4·4
1935	45·0	16·2	36·2	2·6
1938	33·9	21·6	42·3	2·2

is significant here: it shows that in spite of the fact that the children of workers and peasants were given preference from 1917 until about 1930, the proportion of such children in the universities has not risen in any startling fashion, though there was a great increase in the numbers of workers' children in the universities after 1925.

Complete academic freedom is something that the Russian universities have never shown, and the difference which the Revolution brought can again be covered by the phrase, "The more things change, the more they remain the same." When a leader like Molotov can say "Not all of us have yet rid ourselves of obsequious worship of the West, of capitalist culture," in the same threatening tone that the Nazis, with fingers on their revolver triggers, adopted when they spoke of foreign culture as opposed to German *Kultur*, it is not surprising that the teaching of science in the Russian universities tends to suffer, and also the pursuit of scientific research. Molotov has said that, "Unless one rids oneself of these shameful survivals (such as dependence on the West), one cannot be a real Soviet citizen." This kind of attitude has led to political interference with a number of sciences and the dismissal of a far from negligible number of professors and research workers. Russia is the loser here, as she is in another matter concerned with the universities. Ashby has said (1947) that Kaftanov, Commissar for Higher Education, "plans to exchange university textbooks with foreign universities, and he gives the impression that he would encourage the interchange of students between Russia and other countries." Everyone knows that the promised exchanges do not occur on any significant scale, and one has difficulty in finding any proof that any substantial interchange of students has occurred either. The Russian universities are, in fact, cut off from the universities of most of the rest of the world, and it would be of *material* advantage at least to Russia if this particular barrier to the progress of science were removed. Until that happens university education in Russia loses a great many things worth having, and it also reduces its own internal efficiency, which should be a matter of great concern to the rulers of Russia.

Two incidents, details about which have come to light within the past month, show just how impossible it has now become for Soviet teachers to keep up with every new intrusion of the party line into academic affairs. The first concerns chemistry; according to *Pravda*, a congress of Soviet 'scientific workers' have damned the resonance theory of Linus Pauling and four Soviet chemists who supported this "pseudoscientific and vicious" theory—also described as "an example of world outlooks hostile to the Marxist view." The other is the new purge of Russian history (documented in *The Economist* of October 6, 1951, p. 808): officialdom has decreed that Tsarist generals and their soldiers must be glorified, a line which was favoured in the 1930's when war seemed likely but which was reversed in 1945 when Stalin had become The Generalissimo and the Russian marshals went into temporary eclipse; one Russian historian has had his Stalin Prize cancelled for having praised a Caucasian national leader, who fought against Tsarist Russia and who is now decried as "an English agent."

Sodium Chloride: The Salt of Life

J. A. PARSONS

SODIUM CHLORIDE is one of the substances that are almost inseparable from living organisms, and for most animals it is quite indispensable. It is the salt of life, and this association of salt and life is a very ancient one.

There is still no complete and satisfactory answer to the question "What is Life?" and this is true whether one hopes to be able to find an answer in chemical terms or in some other terms. But it is now supposed that in the cooling mass of the earth, after an indefinite period of undirected activity, there came to exist a molecule or system of molecules which was able to create a duplicate of itself, absorbing chemical compounds from the surrounding substrate to support this process.

Our knowledge has at last reached a stage where it is possible to put forward a tentative sequence of changes by which such a system might arise. This has recently been done by Prof. J. D. Bernal.* He sketches a process by which molecular systems might come to life and die again but could not maintain themselves, starving to death because they lacked the necessary supply of sufficiently elaborate organic chemicals. This event would recur countless times before eventually a chemical system materialised which had the right assemblage of chemical reactions to render the system capable of carrying on a process of photosynthesis: in other words, the first plant had appeared on the earth.

It is now almost unquestioned that life began in the sea. The great majority of chemical changes occur in an ionising solvent such as water, and it is usual for biochemical reactions to require the presence of electrolytes. In the primitive ocean the most important salts were the chlorides of sodium, potassium and magnesium, and their ions today form the essential inorganic background of life.

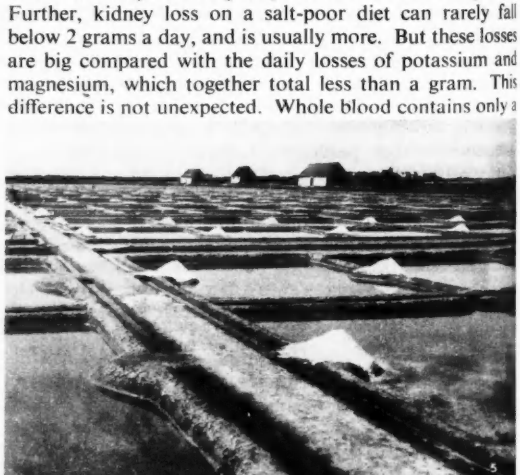
What is perhaps more curious is the narrowness of the limits of concentration in which the various ions must be present for any cell to live. Bernard's dictum *La fixité du milieu intérieur est la condition de la vie libre* is rigidly true of saline concentration, just as it is of hydrogen-ion concentration and temperature.

Macallum calls the inorganic constituents of cells, the body fluids, 'paleo-chemical endowments', which conveys the idea that the concentrations and relative proportions of ions they contain are more or less directly derived from the composition of the ocean at certain periods in the past when the first living organisms evolved. Geologists believe that the primitive ocean contained relatively much more potassium and less magnesium than does the ocean of the present day, and that the total salinity was lower.†

This agrees well with the observed fact that the fluids within animal cells are richer in potassium than is plasma; in contrast, almost all animal magnesium is concentrated in the plasma and the fluids that fill the spaces *between* the cells—the *inter*cellular fluids as opposed to the *intra* cellular spaces. The cell itself is of course thought to have closed off from its environment far earlier than body fluid systems. The theory as originally stated is certainly over-simplified, but there is no doubt that it embodies an important truth—namely, that the inorganic skeleton around which organic processes occur has common features for all living things. For the most diverse forms of life, similarities of inorganic content are more striking than any differences.

Salt is essential for life; both men and animals recognise this by their behaviour. The concentration of sodium in the blood, like that of most other ions, is controlled by the kidneys, and its level at any time is balanced between the rates of ingestion and loss. The filter mechanism of the kidney strains off a fluid thought to be identical with plasma as regards inorganic contents, but freed from protein. This is produced at the enormous rate of 100–150 cc. per minute, but 99% of the water and most of the salts are then re-absorbed by special cells forming the walls of the kidney tubules. The result is a concentrated urine containing much urea, and a minimum amount of salt—the the latter increases only when the body has to rid itself of excess.

Urine is not, however, the sole route by which salt leaves the body. A small, almost negligible amount is present in the faeces. Salt is lost in sweat. The sweat loss under temperate conditions is only 0·3–0·4 gram of salt per day, but with heavy sweating may reach more than 4 grams. Further, kidney loss on a salt-poor diet can rarely fall below 2 grams a day, and is usually more. But these losses are big compared with the daily losses of potassium and magnesium, which together total less than a gram. This difference is not unexpected. Whole blood contains only a



Salt pans at Carnac, Brittany, where salt is still made by leaving brine to evaporate in the sun.

* Bernal has now published his ideas on the origin of life in a book entitled *The Physical Basis of Life* (Routledge, London, 1951).

† The increase in the salinity of the oceans has been due to the fact that salts have been continually washed out from the land and carried down, dissolved in river water, to the sea; in this way salts have accumulated in the oceans, the total volume of water in the seas remaining constant as long as evaporation losses balance the gains due to precipitation. The amount of sodium chloride in seas water is related to the age of the earth, and estimates based on this give an age of 500–700 million years, which is of the same order of the estimate of about 2000 million years for the oldest mineral speciments that scientists have dated.

little magnesium, and although the amounts of potassium and sodium are almost the same, only the sodium is present in plasma, the potassium being held within the semi-permeable membranes of the red blood corpuscles.

It follows that sodium chloride is the only one of the salts needed by the body to which special attention needs to be given when considering the diet. McCance puts the salt requirement at no higher than 3–6 grams a day. This amount is probably adequate where there is mild exertion in a temperate climate; other estimates suggest 10–15 grams per day, and if such a ration is generous, that is preferable to erring in the other direction.

TABLE I

Sodium chloride content of various foodstuffs (in milligrams per 100 grams)

Meat	65–80	Cereals	5–30
Milk	43	Potatoes	3– 4
Eggs	185	Vegetables, green	3–15
Liver, brain, kidney	110–160	Vegetables, root	10–60
Fish	120–190	Fruit	0– 3
		Nuts	2–10

Table I gives the salt content of a number of foodstuffs. A glance at this table is enough to show why primitive people living on a diet largely of milk and meat rarely need to add salt to their food. Salt becomes indispensable to man only when he eats large quantities of vegetables and fruit. Herbivorous animals in general need supplies of salt, whereas carnivores do not. A high proportion of the salts present in raw food are washed out in cooking, so that salt needs to be added to the food when it is being cooked, or when it is about to be eaten.

It is interesting to select a community with a minimum of industrial uses for salt, and calculate the actual demand. This kind of data is hard to obtain, but in certain agricultural districts of India we find that the average daily consumption works out at 16·5 grams per head. This agrees well with the estimates already quoted. In France the salt sold for domestic use is recorded separately, and here we get the figure of 26 grams per head per day (1948); part of this would go into domestic uses other than cooking and use as table salt. For Britain total consumption (i.e production plus imports, less exports) was about 170 grams per head per day in 1948; this figure includes all the salt used for industrial purposes, and is one of the highest in the world.

Severe salt deficiency can cause serious consequences. A slight lack of salt commonly causes attacks of cramp, and this kind of cramp can be miraculously relieved by drinking a spoonful of salt in water: miners in many Welsh pits traditionally salt their beer as a preventive. In 1936 Dr. McCance kept a group of volunteers on a practically salt-free diet, and made them sweat profusely each day in a hot chamber. After 4 to 8 days most of them experienced nausea, lassitude and fatigue; sometimes there was breathlessness on the least exertion. Their symptoms closely resembled, in fact, those of Addison's disease, in which there is great disturbance of kidney function with abnormal loss of salt. (In Addison's disease the excretion of nitrogen waste is also disturbed, and uraemia develops; this too occurred during Dr. McCance's experiment).

Salt is involved in other physiological activities and these are also affected by salt deficiency. Some eight litres of digestive fluids are poured into the alimentary canal each day, and these contain large amounts of salt; moreover, hydrochloric acid from the stomach meets and reacts with bicarbonate from the pancreas to form salt. Normally all the salt is re-absorbed in the gut.

Derangement of nutrition during salt starvation can be extreme; it has often been observed that animals fed on a diet lacking salt die far more quickly than those starved completely.

Trading and Taxation

A material like salt, which is essential and not merely useful or attractive, has an indefinite value which is related to the ease with which it is obtained. In districts remote from salt mines the price has often been enormous; the highest prices have been reported from all parts of the East. Conditions there are well illustrated by a typical account, that of Francis Alvarez, a Portuguese missionary who was sent on an embassy to the Negus in 1520, and spent six years in Abyssinia. He wrote, *Salt is current instead of money from the Red Sea to Congo on the West Sea. It is said to be dug out of mountains and cut into blocks a hand-and-half in length, 4 fingers broad and 3 fingers thick. When dug out 100 or 120 of these blocks were worth ¾ of a ducat; a day's journey distant 5 or 6 blocks less were worth the ¾ ducat; at the King's Court 6 or 7 blocks were worth this money and as it travelled farther one block would purchase a slave and it became nearly worth its weight in gold.*

In countries all over the world where salt had such value it was used as money. Marco Polo speaks of the use in China of carefully cast moulds of salt, each impressed with a stamp of the Great Khan's head. Even recently salt money could be found in Africa, Borneo, China and other parts of the East. In Yunnan there is every reason to think that the custom is still maintained, and in Abyssinia, salt bars were legal tender, even for fines and taxes, as recently as 1933.

Taxation of salt is nearly as old as the salt trade—and commerce in the mineral is certainly as ancient as the annals of the Chinese Emperor Yu (2205–2197 B.C.), which are among the earliest records where it is mentioned. Certainly the Ptolemies in Egypt and the Seleucids in Syria held salt monopolies, and the State salt monopoly of Rome was well developed. At least two of these early fiscal arrangements were adopted in other countries, the essence of the system passing by example or by direct continuity of legislation from one empire to another. The Roman system inspired the *gabelle* in France, and nearly all the recent European salt taxes were based on the Roman or the French model. Similarly, a line of descent has been traced from the Arab tolls levied under the Great Mogul Empire to the British Government monopoly in India, first organised by Warren Hastings.

It is hard to obtain clear information about the salt taxes in force in different countries today. These taxes are rarely imposed directly, but operate through a government monopoly in the mineral. The monopoly price may include only a small tax, the existence of which is not obvious to the public. Alternatively the tax may be very high; in this case provision of salt used for preserving and agricultural purposes has to be made at a special low rate. Here great

vigilance and expense becomes necessary if fraud is to be prevented. In nineteenth-century Prussia, agricultural salt was sold at a tenth of the monopoly price, and was dyed pink with a harmless vegetable colour—a measure which reduces the novelty of the practice of colouring commercial petrol. It was forbidden to use pink salt in the cooking-pot or at table, but naturally the ban was hard to enforce.

In England, Elizabeth and her advisers cast covetous glances at the French system, and attempts were made to introduce a salt monopoly on the Roman model. Exclusive concessions were granted to foreign adventurers who claimed special knowledge of the salt trade, and provision for substantial royalties to the Crown was written into their patents. The schemes did not succeed, however, and a salt tax was first introduced as an emergency measure in the reign of William III. It was foreshadowed for some years by the excise arrangements in force under the Commonwealth, which affected salt among many other products. The duty was increased from time to time until in the nineteenth century it was £30 a ton—whereas the cost of production was only £1 a ton. Supplies were allowed duty-free for export and to fisheries, so that control of fraud became exceedingly difficult. Great quantities were exported to Ireland—and then smuggled back again. Eventually the public refused to tolerate the salt duty any longer. It was reduced in 1824, and abolished in the following year. In Norway the salt tax disappeared in 1844, and in Portugal in 1846. But, as late as 1915, Calvert was able to say that, apart from these exceptions, nearly every country had some form of tax on the mineral.

Of all taxes on salt, probably the most notorious have been the French *gabelle* and the British salt tax, in India, each of which had a big effect on the country's history. The *gabelle* gave rise to a network of corruptions and intrigue, and this chapter in the history of taxation is doubly fascinating because of the original innocence of its purpose. Under a statute of 1315 Royal granaries were set up in many parts of France, to which all salt was to be brought before sale. This measure was much needed in order to protect the people against a few powerful monopolists. Originally it was never intended to provide a revenue; its function was to fix maximum selling prices, allowing the seller to make only a reasonable profit. But once the mechanism existed, it was only too easy to impose a salt tax, and the first temporary levy was exacted in 1342. This was not removed, and the system began its weird proliferation. From the first there was no uniformity throughout the provinces of France: some provinces were salt producers, others were only salt consumers, and then the provinces periodically changed their allegiance—some were attached to and others were independent of the King of France. Thus arose all kinds of special exemptions from the tax and hereditary privileges innumerable. In time the structure grew almost too complicated for any one man to grasp. From the very beginning evasion could not be prevented, and it may be said that the exertions of smugglers and special police in this connexion grew side by side throughout the history of the salt tax.

The worst evils of the tax followed the introduction of the tax-farming system by Francois I. To raise ready cash, he sold—to individuals or to syndicates—the rights to the salt tax year by year. Buyers had their own militia to enforce the collection of the salt tax, so the exercise of authority became separated from the King's responsibility. In the last years of the tax, the incredible number of 3500 citizens of every age and sex were condemned to death every year, or to forced labour or prison for offences against the salt laws alone. There is little doubt that the tax was one of the causes of the French Revolution. The salt tax was revoked by the King in 1790, in that first brief period of revolution. All persons under sentences for crimes against the salt laws were then reprieved. An infinitely more logical salt tax was later imposed by Napoleon to finance his Italian campaign, and the ugliness and power for evil of the old system never rose again.

In India, Gandhi selected at the outset of his 'civil disobedience' campaign the Salt Laws as the point of greatest injustice. The choice contrasted vividly Gandhi's ideal principle of natural justice, and the policy of sheer, convenient expediency to which governments commonly cling. It was not that the amount of the tax was high—it worked out at less than a penny a head, at a consumption of one pound of salt a month. But the very existence of the salt monopoly meant oppression to Gandhi's party. Along much of India's 3000 mile coastline, crystalline salt can be picked up from the sand. Elsewhere it is formed in any dish of sea water that is left in the open. Yet the law was that possession of any salt not obtained from the monopoly was a criminal offence.

Following the decision by the Congress Party that a campaign for independence should begin, Gandhi served notice of 'civil disobedience' on the Viceroy. He had previously given an interview to H. N. Brailsford for the *Manchester Guardian*, in the course of which he said: "*Why, they even tax our salt—a necessity of life, only less necessary than water and air. It ought to be as free as those are. I know you pay a rate for water in England, but this salt tax is worse than a rate. It's a monopoly.*"

On March 12, 1930 he set out and walked for twenty-four days south to the sea with a growing army of disciples. He picked up some salt left by the waves, and this was later sold for 1600 rupees. The campaign of civil disobedience was launched. Nearly every villager on the coast of India went to the beach to make salt, and the Government retaliated by making mass arrests. Pandit Nehru, now Prime Minister of India, was among the Congress leaders taken to court under the Salt Acts, and he received six months imprisonment. Non-violent disregard of other laws followed, and in a few months 60,000 political offenders were in jail; all India was seething in angry revolt and the conflagration had been touched off by the one simple, symbolic act of defiance against the salt laws.

In March 1947 (less than a year before his death) Gandhi was to see Congress, in an India on the verge of independence, repeal the tax and the Salt Laws. The *Eastern Economist* could then say, "One thing is clear: this is a concession to the memory of a historic agitation, and the idea that abolition is going to bring any significant relief to the poor is simply not true." But the unjust monopoly, symbol of foreign rule was dead.

The second part of this article, dealing with the mining, purification and uses of salt will appear in the December issue.

The British Association in Edinburgh*

Artificial Rain

A WHOLE session was given up by the Physics Section to a discussion of the fundamentals of cloud-formation and precipitation—i.e. the falling of rain or snow or hail.

There were five papers, by B. J. Mason (lecturer in meteorology at Imperial College), F. H. Ludham (a research student at the same college), I. C. Browne of the Cavendish Laboratory, R. F. Jones of the Meteorological Office, and A. W. Brewer of the Department of Meteorology of Oxford University. Caution in the interpretation of results already achieved was advocated by most of the speakers.

Mr. Mason's paper was concerned with the fundamental physics of precipitation. He showed that clouds consist of minute water droplets of radius between 1 and 10 microns (1 micron = a millionth of a metre), and that a drizzle consisted of drops bigger than 100 microns, whereas raindrops had a radius of between 200 microns and 2·5 millimetres. The fundamental physics rested in the mechanism by means of which the tiny cloud droplets became big enough for precipitation. The seeding of clouds from above with dry ice or from below by silver-iodide smoke had been used, and a very recent development was the injection of water droplets from below, a technique that promises to be the most efficient method of inducing precipitation from shower-clouds.

The important questions are: (*a*) how much can seeding techniques produce rain that would not fall naturally, and (*b*) whether the time of release, and hence the distribution, can be altered. It is possible that seeding will advance the precipitation from a cumulus cloud by a few minutes and from frontal cloud systems by a few hours. This might be of importance in increasing the rainfall in a limited area, although judging the optimum time for seeding would in most cases be very difficult. "Suggestions of seriously influencing the weather on a large scale by such methods come mainly from non-meteorologists who have failed to take the complex meteorological factors fully into account. The energy released by seeding a large cumulus cloud could not possibly build up on a large scale."

Mr. Ludham gave some details of the natural and artificial production of showers. The important factor in the production of precipitation is the time element. Warm upward currents inject droplets into the base of a cumulus cloud. As these rise they get bigger, but the important aspect of the increase is whether the rising droplets get big enough for precipitation, and it is possible for droplets to emerge at the top of the cloud in a detached portion that is dissipated, the result being no precipitation. The time of rise is of the order of ten minutes. He gave graphs showing that in cold climates precipitation by means of ice occurred at a much lower level above ground than by the coalescence of rising drops, whereas in warm places the opposite was the case. In temperate places both techniques occurred at about the same height. He emphasised that the data do not exist to justify generalisation on the techniques—we do not know.

Dr. Brewer devoted his paper to a discussion of the role played by ice nuclei in precipitation, a role that is the basis of the older seeding techniques and, on the whole, of the natural production of rain in this country. Concentrations of ice nuclei have been measured in Prague and at Oxford, but the ice-forming nuclei active at −10° C., the temperature necessary for the growth of ice crystals that will produce precipitation, are very rare. So it seems that the ice crystals must 'breed' during their growth. Ice crystals that are growing fast are very liable to fracture, with the release of small splinters of ice. It is probable that several splinters are formed at each fracture, and then these grow and fracture in turn, releasing more splinters. In this way a sufficient number of ice particles will be formed. Once the ice particles are larger than the surrounding water droplets, the process of growth by coagulation becomes important. In this way a reasonable qualitative account can be given of the processes that occur in the formation of raindrops from ice nuclei.

The 'Blue' Sun

MR. R. Wilson of the Royal Observatory at Edinburgh gave to Section A (Physics) the most convincing account yet to appear of the 'blue-sun' phenomenon of September 26, 1950, coupling with his explanation an excursion into the physics of the scattering of light by small particles. The old elementary textbook theory of this has often been called on to explain the blue of the sky and the red of sunset. Clearly, on this basis the sun could not look blue by transmitted light. It was seen that this old explanation is only a part of the whole story.

Mr. Wilson's own actions were an example of prompt response. He was on the ground floor of the observatory when telephone messages began to come in about the very odd fact that Edinburgh people were seeing a deep-blue sun. He immediately loaded photographic plates and rushed up to the 36-inch reflecting telescope, which he trained on the sun. There was cloud about and the sun only appeared clearly in a cloudless sky for a few minutes. Within this time he succeeded in getting three spectrographic records showing the quantity of each wavelength of the light transmitted by the sun when it looked blue. He next looked up the literature of scattering in order to arrive at some understanding of the phenomenon he had just seen.

He found that the basis had been laid by C. Mie, a German, in 1908, in an elaborate and intricate analysis of what would happen to electromagnetic waves when they met particles of small size. This analysis was achieved by using the mathematics of Maxwell's equations. The result was so involved that hardly anyone had been able to compute the final formulae for specific sizes and refractive indices of the material making the particles. In fact it took months to produce even a few points to plot on a graph. Van de Holst as recently as 1946 changed the Mie formulae slightly by juggling with the variables used and some computations were made. The result of this work was to show that the physical effect produced by the interposition of small particles or drops in the way of light consisting of a mixture of light of different wavelengths depended fairly critically on the size of particle, the refractive index of the material and the wavelength of the light. It was seen that the phenomenon of scattering is really the result of the interference between light transmitted through each particle and that passing round the edges. From the Mie analysis and Van de Holst's modification a calculation could be made of the quantity of light transmitted (or, alternatively, lost to direct vision) for every wavelength of light if an assumption was made about the refractive index of the material and the diameter of the particle. The novel conclusion was that the commonly accepted form of scattering in which the blue part is scattered and the red transmitted applies only when the particles are less than a tenth of a micron in diameter, a micron being a millionth of a metre. For particles bigger than this, still in relation to sunshine through air, it could happen that actually the blue would be transmitted and the red scattered or extinguished for direct vision. Whether it would happen or not depended also on the refractive index of the particle-material.

Other evidence showed what the particles in the case under investigation were made of. Extensive forest fires were burning in Alberta, Canada, on September 23, 1950. The smoke from these fires drifted over North America, across the Atlantic, over the British Isles and then across to Europe before it finally dispersed. Mr. Wilson did some spectrographic photography on the sun when unobstructed by smoke and so obtained the quantity of light of each wavelength present. By comparing this with the results obtained by the photography of the 'blue' sun he was able to calculate the light extinguished during the phenomenon. This extinction was plotted on a graph for a certain size of transparent particle, and

* *This concludes our report of the 113th annual meeting of the British Association; the September issue contained the presidential address of the Duke of Edinburgh, and the October issue carried 6 pages of the sectional presidential addresses.*

this graph agreed remarkably with the theoretical one produced from the Mie and Van de Holst formulae. This experimental verification of the theory enabled Mr. Wilson to arrive at the size of particle which he estimated to be about *one sixth of a micron*. In addition the particles were transparent. The only transparent substance likely to be produced from wood was an oil. That this was so was confirmed by the evidence of airmen flying through the smoke at a height between 30,000 and 40,000 feet on the occasion of the 'blue' sun. They reported a film of oil on the aircraft.

The conclusion of this piece of work, therefore, was that the Mie and Van de Holst theory was confirmed and that the 'blue' sun was caused by the scattering of sunlight by transparent drops of oil of diameter about a sixth of a micron, the effect being that blue light was transmitted and red light extinguished to direct vision. Further work showed that there was also a neutral absorbing layer that did not distinguish between wavelengths. This layer was considered to consist of the carbon particles that would be expected in smoke from a fire. The phenomenon of blueness has been noticed before on the occasion of volcanic eruptions, especially that of Krakatoa in the 'eighties of last century. On this latest occasion, the moon was also 'blued' as the layer drifted across on its course eastwards. The relative rareness of the phenomenon is of course the origin of the expression "once in a blue moon".

The Luminous Night Cloud

MR. J. PATON, senior lecturer at the University of Edinburgh, gave to the British Association meeting some account of his experimental work on aurorae. Four stations situated in different parts of Scotland took part, and by means of specially designed cameras and interstation telephonic communication, simultaneous photographs have been obtained of aurorae and their characteristics calculated. He also said something of another phenomenon considerably less known than aurorae and associated with Mr. Wilson's explanation of scattering. It is the phenomenon known as the *luminous night cloud*. At times in a cloudless sky in the dark of night there appear in the north parallel lines of brilliant blue clouds. The height of these has been calculated to be about fifty miles. The cause of the light is just that the height of the clouds is enough for the summer sun to light them when we are in darkness and that the blue light of the sunshine is scattered just as it is during the cloudless summer day. The particles that make up these clouds must therefore be very small. At one time they were thought to be dust particles or other particles of volcanic origin. It is now believed, however, that their origin is cosmic and in fact they may even be water droplets.

Physiology and Mining

THE Physiology Section, showed its interest and sympathy with the lot of common folk when it held a symposium on the physiological problems of mining. These are problems, of course, of particular interest to many who live and work in the neighbourhood of Edinburgh. The session started appropriately with a tribute to J. S. Haldane, the physiologist who contributed so much to the safety and welfare of miners and who was born and educated in Edinburgh. He, as Dr. R. Passmore, lecturer in Industrial Physiology at Edinburgh University, said, "drew no sharp distinction between pure and applied science; to Haldane the welfare of mankind was the fulfilment of the growth of knowledge."

Dr. C. G. Gooding dealt with the effect of lighting on the health and working efficiency of miners. The amount of lighting concomitant with safety was so small until 25 years ago, he said, that the miner was unable to use the most efficient part of his vision. This led to miner's nystagmus with its deleterious effects on vision followed by many neurotic symptoms. Here he quoted evidence to show that the disease was physical in origin and not, as maintained by some psychologists, a neurotic disease arising from a desire to escape from the dangers of the pit. The improvement in lighting with the introduction of the electric cap lamp 25 years ago, and more lately with fixed fluorescent lighting, held out hopes that eventually the disease might be eradicated. It was less common than 30 years ago but even so, between 1938 and 1947, 14,000 miners were disabled for one year or more. There was little evidence so far, Dr. Gooding said, that improved lighting increased output or enhanced safety, although it seemed to result in cleaner coal. The most important result was that the increased comfort of better lighting would bring an increase in efficiency and "work a revolutionary change in the psychological climate of the industry by converting mines into underground factories".

"There is no object so foul," concluded Dr. Gooding, quoting Emerson, "that intense light will not make it beautiful."

The latest ideas on the effects of dust inhalation on miners were expounded by Dr. C. M. Fletcher, director of the pneumoconiosis research unit at Llandough Hospital. It was the inhalation of coal dust itself and not associated stone dust which was responsible for pneumoconiosis, he said. It was not known why its prevalence in South Wales was greater than in the rest of the country's coalfields put together. Simple pneumoconiosis did not bring a respiratory efficiency lower than that of the unaffected miner, but as the miner's respiratory efficiency was so much lower than that of the average worker in other industries, extended research was required into the causes of this.

Dr. A. Meiklejohn, lecturer in industrial health, Glasgow University, had definite ideas as to why the incidence of pneumoconiosis was so outstanding in South Wales. It was merely, he suggested, that examination was much more thorough there. Recently more widespread examination in other coalfields had been reflected in rising pneumoconiosis statistics.

He said, "The increased dust due to increased mechanisation must be combated and it was a problem and a challenge for both sides of the industry to solve themselves, leaving 'politics' aside. It was a question whether the increased mechanisation springing from our increased demand for coal would not eventually diminish output by its deleterious effect on the miners themselves."

The Changing Face of the Chemical Industry

ONE of the most impressive papers delivered to the Chemistry Section was that by H. W. Cremer, a leading chemical engineer, who sketched the great changes in the pattern of the Chemical Industry which have resulted from the ever-increasing participation of science in the manufacturing processes. He began by dealing with some of the ill effects which were produced by the somewhat haphazard early development of chemical industry, which led to pollution of earth, sky and water—a phenomenon which the general public came to regard as almost inseparable from such industry. Only recently had it been realised that many of the offending industrial operations could be carried out much more efficiently in surroundings which are clean and wholesome, *and without* violation of the neighbourhood in which they are conducted. "But even today, particularly so far as pollution of the atmosphere and of streams, rivers and estuaries is concerned, there are still persons who have to be constrained *by legislation* to do what some might suppose they would do by instinct," though Mr. Cremer added that such people were in the minority and represented an expression of the careless way of life of that early period.

"Like Pandora's Box, the casket which the pioneers of chemical industry opened contained both good and evil things. But it is well to remember that after everything else had escaped, Hope remained in the Box—Hope, which can be defined as *the recognition of better things in store, accompanied with all due effort to gain them.* I believe that we do in fact enjoy far better things as a result of such efforts."

The early industry concentrated on *quantity* of output, and wastage of raw material and the disposal of by-products did not unduly concern it so long as there was no actual infringement of existing laws. Competition from the factories of Europe and the U.S.A. produced an urge for higher efficiency at the same time as the public was becoming aware of the need to prevent pollution of the atmosphere and of water.

"Today (unless specially subsidised) only manufacturing operations that are carried out under conditions of high efficiency can expect to survive. This is one of the more obvious factors which has changed the face of the industry," commented Mr. Cremer. Another, but less obvious, factor is the increasing emphasis on Fine Chemicals as opposed to Heavy Chemicals. The rapid developments of organic chemistry were the basis of the growth of the Fine Chemical Industry.

"Today it may be said that applied chemistry contributes to almost every

requirement for man's existence and well-being. As an infant he may be reared on a chemical food—in fact, his sustenance throughout life now depends largely on the industry's contributions to nutrition. Such items as sulphonamides and antibiotics (e.g. penicillin) have revolutionised the treatment of disease. Not only are synthetic dyes produced in quantity and great variety, but the fabrics on which they are used are increasingly the product of the chemical factory. Likewise cosmetics and perfumes, wherewith the female of the species embellishes her natural attractiveness, are also largely products of the chemical industry. Today in addition to soap (obtained from animal and vegetable sources) there are synthetic detergents derived from mineral sources such as petroleum." Mr. Cremer also referred to fertilisers, insecticides, 'hormone' weed-killers, the chemicals used for water-softening—all examples which illustrate man's debt to applied chemistry, which also affect his cultural pursuits and entertainment during his leisure hours.

The boundaries of this industry cover an immensely wide field and cannot be defined with exactness. For example, foods and medicinal substances, many of which are heat-sensitive and capable of putrefaction—must be produced under conditions of strict cleanliness involving extremely carefully controlled techniques.

"This changing background has brought marked changes within the industry itself. A very important one is that no longer is it considered inevitable that a chemical factory, whether producing Heavy or Fine chemicals, must constitute an unsightly excrescence to town or countryside. A modern sulphuric-acid works, whether using the contact process or the old chamber process, is hardly distinguished externally from a bakery or a dairy: it interferes no more with the amenities of the neighbourhood. Modern chemical plants tend to exhibit architectural features far superior to those of many non-industrial buildings. The trend is, I believe, towards creating pleasant, even noble structures. The idea that chemical industry must denote foulness and unsightliness is being dispelled. To my simple tastes, a good modern factory is more attractive than the more exotic forms of modern art."

Mr. Cremer described the way in which chemical engineering has integrated the various sciences to the benefit of the industry, which uses the services of mathematicians, physicists, chemists, biologists, geologists and metallurgists. He said that this is immensely important in solving the extremely intricate problems characteristic of modern chemical production. Originally the industry depended on the mechanisation of chemical process by the mechanical engineer. "Chemical engineering as a term dates back to the end of the nineteenth century, when it was realised that this was more than a promiscuous compounding of chemistry and mechanical engineering. Today it is accepted that most industries are in a sense chemical industries and that chemical engineering is not less important than mechanical and electrical engineering in servicing them. This concept has been most significant so far as the design of process equipment and the general approach to industrial problems are concerned. But there has been a failure in Britain to recognise that chemical engineering needs an educational discipline of its own. Here British industry has lagged behind America. Protracted and tortuous negotiations have usually been necessary before new schools of chemical engineering have been established in Britain. Hence the most embarrassing dearth of young chemical engineers."

Of chemical engineering Mr. Cremer said: "Few other professions have taken such trouble to create in the minds of their initiates such a blend of the pure and applied sciences, such an appreciation of good and bad where manufacturing technique is concerned, and to equate these with that knowledge of mankind and its habits without which a really balanced judgment cannot be reached; nor that forward-looking which the creator of industries has all too frequently lacked in the past."

The co-operation between pure and applied scientists and technologists is improving, but Mr. Cremer saw a need for industrial experts to return to, even to be *enticed* back to, the universities. "I look forward to the universities being enriched by scientific minds which have ripened in an industrial environment."

Mr. Cremer closed his speech by expressing the hope that his listeners had been persuaded to share his view that there is now a much better prospect that Chemistry can be properly wedded to Industry and in turn Chemical Industry to Civilisation.

B.A. Excursions

NUMEROUS excursions were made to places of scientific interest during the British Association meeting. One of the most interesting was that made to the Institute of Seaweed Research just outside Edinburgh. Scotland had the first chemical industry based on seaweed, which from the beginning of the eighteenth century was burnt to form kelp. For a century kelp was the only source of sodium carbonate for the glass and soap industries but the seaweed industry was killed by alternative processes and sources. It revived temporarily with the discovery that iodine and potassium salts could be produced from seaweed, only to meet the same fate in the latter half of the last century.

In 1944 the Scottish Seaweed Research Association was set up to investigate the possibilities of establishing a seaweed industry in this country capable of competing with those abroad, a project that has become more important with the increasing shortage of raw materials. Alginates from seaweed were first developed commercially here in 1934, and today six firms are producing £750,000 worth of these seaweed chemicals annually. During the war there were three Government factories in Scotland for producing from this source non-inflammable camouflage material.

The alginates have wide applications in the food, pharmaceutical, rubber, paint, paper, and textile industries. One of the better-known uses is the admixture of alginate yarn in weaving woollen and other textiles and its subsequent dissolution to give light-weight fabrics.

Night Sky in November

The Moon.—Full moon occurs on Nov. 13d 15h 52m, U.T., and new moon on Nov. 29d 01h 00m. The following conjunctions with the moon take place:

November				
10d 06h	Jupiter in conjunction with the moon	Jupiter	4°	S.
24d 11h	Mars ,,	Mars	4°	N.
25d 10h	Saturn ,,	Saturn	6°	N.
25d 18h	Venus ,,	Venus	6°	N.
30d 14h	Mercury ,,	Mercury	2°	N.

In addition to these conjunctions with the moon, Venus is in conjunction with Saturn on Nov. 21d 10h, Venus being 0.6° S.

The Planets.—Mercury is too close to the sun during the first half of the month to be seen but on Nov. 30 it sets an hour after sunset and can be seen for a short time in the western sky. The planet attains its greatest easterly elongation on Nov. 28 when 0·67 of its illuminated disk is visible and its stellar magnitude is −0·1, which implies that it is brighter than Vega. Venus, a morning star, rises at 2h 35m, and 3h 20m, at the beginning and end of the month, respectively. It reaches its greatest westerly elongation on Nov. 14 when its stellar magnitude is −4 and half its illuminated disk is visible. Mars a morning star, rises about 2h from Nov. 1 to 15, and at 1h 35m on Nov. 30. About the middle of the month the planet is close to β Virginis, and at the end of the month is close to η Virginis. Jupiter is visible throughout the night, setting at 3h 45m, 2h 45m, and 1h 45m, at the beginning, middle, and end of the month, respectively. Saturn is a morning star, rising at 4h 10m, 3h 20m, and 2h 30m on Nov. 1, 15, and 30, respectively. In the early portion of the month the planet is a little south of γ Virginis.

The constellation Cygnus is nearly overhead in the early evening hours during November and contains many interesting objects. The brilliance of the Milky Way is noticeable and β Cygni—a third magnitude star—is a beautiful object when viewed through a small telescope or even a field-glass. This star is a double, the larger star being a golden yellow and its companion a sapphire blue. As they are more than half a minute of arc apart they are not difficult to separate with optical aid. If there is any doubt about identifying this star, notice that it is close to the constellation Lyra and in a line with the two brighter stars of Cygnus, α and μ, and three times as far from γ as this star is from α.

The Bookshelf

Flies of the British Isles. By Charles N. Coyler, F.R.E.S., in collaboration with Cyril O. Hammond, F.R.E.S. (London, Warne, 1951, 383 pp., 30*s*.).

THE DIPTERA—the True Flies—is so large an order of insects that it is extremely difficult to identify many of the species. The result is that few people, other than professional experts, ever attempt to study these insects, which is a pity because their variety is enormous and their life-histories are often extremely interesting. This book fills a gap which has existed for too long, and provides the keen naturalist with a pocket book—a somewhat bulky pocket book, perhaps, for it weighs 23 ounces—which will solve the problem of putting a name to any fly to be found in Britain.

It is in fact the only British work of its kind, giving a profusely illustrated, comprehensive survey of all the families of British Diptera. It deals with structure, life-histories and habitats, and their role in nature. Methods of collecting, rearing, examination and preservation are well explained.

The colour and half-tone plates (from paintings and drawings executed by Mr. Hammond) are magnificently printed. There are also many neat text figures and diagrams.

The keys and summaries of family characters, correlated with the plates and figures, enable the naturalist to identify the species of Diptera he encounters. There are also carefully selected bibliographies at the end of each chapter to furnish quick reference to useful works on the different families of flies, thus opening up further fields of interesting reading and study.

The Measurement of Radio Isotopes. By Denis Taylor. (London, Methuen, 1951, 128 pp., 6*s*. 6*d*.).

THE increasing use of radioactive isotopes in universities and hospitals and in industry has created a widespread interest in methods of measuring radioactive sources. Dr. Taylor's book is intended to describe the fundamental principles, standard equipment and methods employed to the newcomer to the field who wishes to use radioactive isotopes as a means to an end. Chapters are included on the fundamental facts about radio isotopes, measuring apparatus, counting systems, statistics, source geometry, methods of measurement and correction, and finally health hazards. These would seem to cover the subject adequately, but many workers in this field will notice a number of important omissions. The method of measuring γ-radiation with ionisation chambers, which is a well-known technique of long standing, is barely mentioned. Absolute measurement is dealt with very briefly, and only two direct methods are mentioned, whereas at least four important indirect methods are in general use. The brief description of scintillation counters gives no real indication of the potentialities of this important method and the uses to which it has been put, particularly in the United States. The sections on source mounting and back-scatter receive very little attention compared with the detailed account of self-absorption. No mention is made of the use of thin films of nylon, formvar and polystyrene as source mounts, and no quantitative information is offered on the important question of back-scatter.

In several places in this book brief mathematical analysis are given. These will be found confusing by the beginner, and the choice of symbols is particularly unfortunate. For example A is used with three different meanings—atomic number, surface area, and apparently the time integral of the counting rate—in the space of three pages (pp. 68–70). Other similar examples could be quoted. More important, however, is the failure to define μ for the circumstances to which it refers; μ is described as the *linear absorption coefficient* on p. 61 presumably, in this context, for point sources; assuming the same interpretation, the self-absorption anaylsis on p. 70 is incorrect. although the difficulty might be overcome to some extent by clearly re-defining μ as the coefficient of the exponential curve obtained by placing absorbers between a thin plane source and the counter. Values of μ and $d^{\frac{1}{2}}$ are quoted for some isotopes without reference to the source and circumstances under which the measurements were made, which in view of the divergence among reported values is unfortunate.

A method of using filter paper sources wrapped round a counter is referred to as a popular one (p. 35), whereas in fact the method is generally regarded as unsatisfactory and is rarely used.

The appearance of the curve given on p. 7, which is a 'standard' decay curve plotted on two logarithmic scales, will come as a surprise to many who are used to such curves plotted on semi-logarithmic scales.

Although it is obviously not the author's intention to quote original references in detail, there are a number of examples in which the original publications have been ignored. For example, the beta-gamma coincidence method ascribed to Peacock in 1946 is commonly attributed initially to Dunworth in 1940.

The inclusion of the chapter on methods of measurement and corrections is however very welcome, as it details the standard procedure to be adopted in interpreting results in terms of the true activity of the source. The descriptions of electronic apparatus, and the sections on the setting up and testing procedure for counting systems, will be useful to the specialist as well as the beginner. The newcomer to the field will find this book a useful introduction, but he would be unwise to regard it as an entirely comprehensive survey of the subject, and some of the analyses should be accepted with reserve. W. K. S.

English-Russian Technical and Scientific Dictionary. (Compiled by I. Chernuchin, London, Allen & Unwin, New York, International University Press, 1951, 674 pp., 80*s*.).

THIS is an excellent dictionary but unfortunately it is old, being a reprint of a dictionary originally published in Russia in 1938. (Copies of this reprint were first imported into this country from the U.S.A. during the war.) The original Russian dictionary was superseded in 1946 by the English-Russian Polytechnical Dictionary, edited by Prof. L. D. Belkind, copies of which are available in this country.

WANTED—LIBRARY ASSISTANT

Library Assistant, male or female, 20–25, required by W. Edwards & Co. (London) Ltd., Vacuum Engineers, Worsley Bridge Road, Lower Sydenham, London, S.E. 26. Some general knowledge of engineering essential. Knowledge of languages desirable. Permanent progressive post concerned with technical inquiries and some aspects of publishing. Initial salary appr. £300 p.a. Applications only from those interested in library and information work as a career.

FARADAY HOUSE ELECTRICAL ENGINEERING
66, Southampton Row, W.C.1.

A 4-year full-time course, which includes practical training with mechanical and electrical engineering firms, for the Faraday House Diploma which is accepted for Graduate Membership of the I.E.E.

For particulars apply Dept. E.

BRITISH MUSEUM (NATURAL HISTORY): SENIOR SCIENTIFIC OFFICERS

The Civil Service Commissioners invite applications for two permanent posts in the Department of Botany. The duties entail research work in the Herbarium and the identification of plants and plant products.

Candidates must have been born on or before 1st August, 1920, and must have a First or Second Class Honours degree in Botany and be well qualified in Systematic Botany. Experience in a Herbarium is desirable.

The Commissioners may at their discretion admit a candidate with high professional attainments, notwithstanding that he or she may not possess the above qualifications.

The London salary scale is £750–£950 for men and £625–£850 for women. Exceptionally a starting salary above the minimum may be granted according to qualifications and experience. The posts carry benefits under Federated Superannuation System for Universities.

Further particulars and forms of application from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4083/51. Completed application forms should be returned not later than 15th November, 1951.

Candidates born between 2nd August, 1920, and 1st August, 1925 (inclusive) may be considered but must apply through the Open Competition under Normal Regulations already announced (No. 3399).

Printed and Published in Great Britain by Jarrold & Sons Ltd., Norwich. *Editorial Office: 244 High Holborn, W.C.1*

SCOVERY

nd $d^{\frac{1}{2}}$ are
hout refer-
cumstances
ents were
divergence
rtunate.
per sources
ferred to as
in fact the
as unsatis-

ve given on
decay curve
scales, will
ho are used
mi-logarith-

the author's
eferences in
examples in
s have been
eta-gamma
to Peacock
initially to

on methods
ons is how-
s the stand-
n interpret-
activity of
f electronic
the setting
or counting
specialist as
ewcomer to
useful intro-
se to regard
ve survey of
he analyses
e. W. K. S.

d Scientific
I. Cher-
Unwin, New
rsity Press,

but unfor-
eprint of a
d in Russia
nt were first
the U.S.A.
nal Russian
1946 by the
Dictionary,
d, copies of
ntry.

SENIOR

rmanent posts
n the Herbar-

920, and must
well qualified

ate with high
ot possess the

0 for women.
ted according
ler Federated

Service Com-
reet, London,
ld be returned

925 (inclusive)
etition under